R E P O R T R E S U M E S

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TO DEVELOP A SYSTEM FOR ANALYZING THE REACTIONS OF TEACHERS AND STUDENTS IN BIOLOGY CLASSES.

BY- PARAKH, JAL S.
CORNELL UNIV., ITHACA, N.Y.

REPORT NUMBER CRP-S-269 PUB DATE 65
REPORT NUMBER BR-5-8040
EDRS PRICE MF-$0.36 HC-$8.00 200P.

DESCRIPTORS- *BIOLOGY, *INTERACTION, *BIOLOGY INSTRUCTION, SCIENCE EDUCATION, *SCIENCE INSTRUCTION, *INTERACTION PROCESS ANALYSIS, SYSTEMS ANALYSIS, SYSTEMS APPROACH, SYSTEMS DEVELOPMENT, ITHACA, NEW YORK

A CATEGORY SYSTEM FOR THE DESCRIPTION AND ANALYSIS OF TEACHER-PUPIL INTERACTION IN HIGH SCHOOL BIOLOGY CLASSES WAS DEVELOPED. IN THE FIRST PHASE, A HETEROGENEOUS SAMPLE OF TEACHERS AND SCHOOLS WAS USED FOR OBSERVATION AND DEVELOPMENT OF THE CATEGORY SYSTEM. OBSERVATIONS WERE MADE OF LECTURE AND LABORATORY SESSIONS, VERBAL AND NONVERBAL CLASSROOM COMMUNICATIONS, AND THE INDIVIDUAL BEHAVIORS OF BOTH TEACHERS AND STUDENTS. IN THE SECOND PHASE, ADDITIONAL TEACHERS AND SCHOOLS WERE OBSERVED, AND THE TENTATIVE CATEGORY SYSTEM WAS REVISED. DATA GATHERED FROM 40 LECTURES AND LABS PLUS 40,000 INDIVIDUAL OBSERVATIONS WERE PROCESSED, AND THE FREQUENCIES OF VARIOUS SEQUENCES OF BEHAVIOR WERE FOUND AND ANALYZED. THE CATEGORIES COVERED FIVE MAJOR DIMENSIONS OF TEACHER-STUDENT BEHAVIOR--(1) EVALUATIVE, (2) COGNITIVE, (3) PROCEDURAL, (4) PUPIL TALK, AND (5) SILENCE. ALLOWANCE WAS ALSO MADE FOR BEHAVIORS THAT COULD NOT BE CATEGORIZED IN THE DIMENSIONS OF THE CATEGORY SYSTEM. THE AUTHOR CONCLUDED THAT TEACHER-PUPIL INTERACTION IN BIOLOGY CAN BE STUDIED IN DETAIL AND THAT INTERACTION ANAYSIS OFFERS SOUND POSSIBILITIES FOR STUDYING SCIENCE TEACHING. HE FURTHER STATED THAT, WHILE THE STUDY PROVIDES A TENTATIVE DESCRIPTION, IT IS NOT AN EVALUATION OR CHARACTERIZATION OF GOOD OR BAD, EFFECTIVE OR INEFFECTIVE TEACHING. (PM)

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COOPERATIVE RESEARCH PROJECT NO. S-269

JAMES S. PARKER

CORNELL UNIVERSITY

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Jal S. Parakh

Cornell University
Ithaca, New York

1965

The research reported herein was supported by the Cooperative Research Program of the Office of Education, U.S. Department of Health, Education, and Welfare.

NOTE

This research project was reported in a dissertation submitted to Cornell University and entitled -- "A STUDY OF TEACHER-PUPIL INTERACTION IN HIGH SCHOOL BIOLOGY CLASSES".

Acknowledgments

This research project could not have been undertaken without the help, guidance, encouragement and willing cooperation of many people. I wish to take this opportunity to express my special thanks to:

Dr. Philip G. Johnson, chairman of the Science Education Division of the School of Education, Cornell University, and chairman of my doctoral committee for his sincere personal interest, encouragement and generous gift of time and counsel.

The members of my graduate committee, Dr. Howard G. Andrus and Dr. J. Paul Leagans, for their unstinting help, interest, encouragement and guidance, both before and during the period of this study.

Dr. Matthew H. Bruce Jr. and Dr. Jason Millman and other faculty members at Cornell University for their criticisms and suggestions in the preparation of the research proposal.

Dr. Frederick H. Stutz, Dean, School of Education and the College of Agriculture for financial assistance in carrying out certain portions of this study.

The staff of the Cornell Computing Center, especially Mr. Donald Burrill and Mrs. Betty Iwan for programming and computing services and to Mr. Lawrence Wightman, graduate student in the School of Education, for allowing us to use and modify his Interaction Analysis Program.

My fellow graduate students, especially Mr. Ray Snider and Mr. Charles Matthews, for many stimulating discussions and for helping in various ways.

All the teachers for their willing participation in the study and the school administrators for allowing me to visit their schools and for

facilitating the arrangements. I regret that the maintenance of anonymity precludes acknowledgment by name.

My wife, Theresa Ann, for her patience, encouragement and immeasurable help and affection.

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CHAPTER 1

INTRODUCTION

Two questions of central importance in education are: "What is good teaching?" and "What are the characteristics of good teachers?" The "answers" to these questions -- or rather the ideas that we have about the nature of teaching and teachers -- have many and far reaching effects. These "answers" affect the selection, training, recruitment, supervision, retention and dismissal of teachers; as well as the kinds of education pupils receive. Hence it is not surprising that most of the research on teaching has been devoted to "Teacher Effectiveness" and related questions. Yet, after approximately 1500 studies in the last seventy years, these questions remain largely unanswered. By and large, the findings are contradictory, inconclusive and applicable only to extremely restricted populations. Ryans (1960) sums up the situation when he states that teacher effectiveness has proved to be an extremely complex and ambiguous concept; and that the numerous studies have failed to provide "universally acceptable definitive answers" to questions such as "What constitutes effective teaching?" and "What are the distinguishing characteristics of competent teachers?"

The failure of such prodigious efforts to provide satisfactory answers to these perennial questions has been attributed by competent reviewers to the following major sources: (1) The many and ambiguous meanings of "good" teaching. (2) Inadequate theoretical conceptualization to guide the research efforts. (3) Attempts to answer a multifaceted and complex question in one fell swoop. (4) A failure to distinguish between objective observation and description of teaching and the

making of value judgments and evaluations on the basis of explicit, or more often, implicit values. (5) The use of inadequate research techniques, such as rating scales, check lists, questionnaires, judgments of supervisory and administrative personnel to distinguish "good" from "poor" teachers.

Within the last decade, various researchers have been advocating the need for a new or different strategy in research on teaching. The major elements of the new strategy can be stated as follows: (1) Teaching must be distinguished from learning and treated as a phenomenon worthy of scientific investigation in its own right (Smith 1962 b.p. 33, Gage 1964). (2) A long period of research must be devoted to first hand, systematic, objective observation of teacher-pupil behavior and the analysis, classification and quantification of the elements or units constituting classroom behavior. (3) The descriptive phase must precede correlational, predictive, or causal studies (Smith et.al. 1962 b.p.8). (4) More sophisticated and comprehensive theoretical "models" must be used to guide well articulated research studies. Levin (1954 p. 102-103) cogently sums up the "new" strategy: "The most complete picture of the teaching process would be to predict from the antecedent conditions to the classroom behavior, and in turn from behavior to pupil effects."

Evidence of the use of the new strategy is increasingly seen in the research literature, especially within the last ten years. Category systems are being developed for use in systematic objective observation of teacher or pupil behavior, or teacher-pupil interaction. An interesting feature is the "borrowing" of the theoretical framework of social interaction and observational techniques from the social sciences, especially social psychology. Parenthetically, the birth of the scientific study of

teaching can be discerned, and a lusty infant it promises to be! The earlier studies of classroom behavior reflected the interest and the influence of social psychologists, such as Thomas (1929), Anderson (1939), Lewin (1939) in the affective aspects of classroom life. The major finding of these studies was that the teacher's style of behavior had a marked effect on the behavior of pupils and on the affective or social-emotional climate of the classroom. The teacher's behavior has been described variously as: Dominative versus Integrative (Anderson 1939), Democratic, Laissez Faire, and Autocratic (Lewin et al. 1939), Learner-centered versus Teacher-centered (Withall 1949). A large measure of credit must be accorded to Flanders for establishing "interaction analysis" as a technique in research on teaching and for stimulating interest in teacher behavior. He has chosen the terms "Direct and Indirect Influence" to describe teacher behavior. A radical departure from the emphasis on the affective or social-emotional aspects of teacher behavior to the "logical operations of teaching" is found in the work of Smith et al. (1962 b.). In short, the point is that a number of fairly general category systems have been developed, predominantly for the description and quantification of the affective climate of classrooms. These systems are general in the sense that they can be used at many grade levels amd for most of the usual school subjects rather than for a given subject. One notable exception is the category system developed by Wright and Proctor (1961) specifically for systematic observation in mathematics classes. It is noteworthy, however, that a search of the literature has not revealed a single category system specifically for the description and analysis of classroom behavior in science classes and laboratories, let alone the specific subject areas of biology, chemistry,

etc. -- a most amazing state of affairs in the light of the tremendous emphasis on Science Education in recent years and a rather serious limitation which provides the "stimulus" for the present study!

Purpose

In the post-sputnik years many new curricula in science have been developed at local as well as state and national levels. In addition to "modernizing," or bringing the subject matter up-to-date, these curricula are supposedly designed to promote, largely via first hand laboratory experiences, an understanding of "the structure of the discipline" and "science as inquiry." Vast amounts of time, money and energy have been expended, not only in writing textbooks and developing associated materials, but also in "re-training" and "up-dating" science teachers. It is incomprehensible to the writer that very few, if any, objective, systematic, first hand observations and analyses have been carried out of what actually happens in science classrooms as teachers teach and pupils learn. One is prompted to ask: Just what is the so called "inquiry approach" or the "discovery approach"? In what observable and reliably quantifiable ways is the classroom behavior of teachers and pupils different in classes using the "new" programs, such as "BSCS Biology," as compared to the "traditional," and how are these observable differences in classroom behavior related to pupils' understanding of science as product and process of inquiry? Watson (1963 p. 1043) raises a similar question when he states: "Without clear, empirical evidence of what sorts of experiences result in what subsequent behaviors or enhanced behaviors, in pupils, we are of necessity proceeding on faith."

In order to significantly improve the teaching of science, we need

to consider, not only the content of science courses, i.e., "what" is taught, but also "how" do teacher and pupils interact in classrooms. It is imperative that we know a great deal more than we presently do about the phenomenon that we call science teaching. The need for determining functional relationships between teacher behaviors and pupil outcomes and the need for theories of science teaching is just as great and urgent as theories of teaching in any other subject matter. The most direct way of studying science teaching is by systematic observation of classroom behavior of teachers and pupils. As mentioned previously, one or more category systems or (systematic) observational techniques -- specifically for science classes and especially laboratory classes -- are needed. But not even one had been reported in the literature at the time the study was undertaken, and the same situation still prevails according to the most recent review of "Teacher-Pupil Interaction" by Amidon and Simon (1965).

The writer's personal experience as a science teacher and his observations of science teaching lead him to question the validity of the fundamental assumption on which existing category systems, such as that of Flanders, is based, viz., "The verbal behavior of an individual is an adequate sample of his total behavior." (Amidon and Flanders 1963 p.5.) A considerable portion of a teacher's behavior in laboratory classes is non-verbal, e.g., demonstrating laboratory techniques, examining pupil's work, preparing solutions, etc. Parenthetically, it was the bewildering complexity, rapidity, and variety of behavior in laboratory classes that constituted the fascination and the appeal for undertaking this study. The writer could not resist the challenge of trying to see some order and some sense in the multitude of behaviors that assault and overwhelm the observer in a high school science laboratory class.

The writer finds himself in agreement with the conclusion reached by Smith (1963 p. 295): "there are many forms of interaction involving all sorts of processes and content ...[the researcher]... will soon discover that the actions and reactions of students and teachers are in considerable measure determined by the requirements of that subject matter."

The present research is addressed to two major problems or questions:

(1) Can a reliable and workable category system be developed for first hand systematic observation of high school biology lecture-discussion-recitation classes and laboratory classes?

(2) What are the observable and quantifiable behaviors that constitute teacher-pupil interaction in high school biology lecture-discussion-recitation classes and laboratory classes?

The present study confined to high school biology teaching is the first small, but hopefully significant, step in a large and complex area of research. This study was conducted in Biology classes rather than in Physics, Chemistry, or General Science classes primarily because of the investigator's greater competence and interest in Biology. However, it is expected that the category system developed for systematic observation and quantitative description of biology classes can be used for:

(1) Research on teacher-pupil interaction in high school biology as well as other science subjects (with necessary modifications).

(2) Pre-service and in-service training of high school biology teachers as well as other science teachers.

Objectives

The objectives of this study are:

1. To develop a category system for first hand systematic observation of teacher-pupil interaction in high school biology lecture-discussion-recitation classes and laboratory classes.

2. To find and adapt a compact, reasonably inexpensive electronic device such that the whispered and low-decibel-level conversation between teacher and pupil at individual laboratory desks can be heard and tape-recorded by the observer with a minimum of intrusion in the class activities.

3. To demonstrate that the category system can be used with a reasonably high degree of reliability by the writer, as well as a person other than the writer, i.e., the category system should have a reasonably high coefficient of inter-observer agreement.

4. To use the category system for direct or on-the-spot categorization of teacher-pupil interaction in high school biology lecture-discussion-recitation classes and laboratory classes and to quantify, analyze and describe the observed classroom behavior.

5. To generate hypotheses and questions for intensive future research.

6. To contribute knowledge towards (a) a clearer conceptualization of science teaching and (b) training of science teachers.

Assumptions

The major assumptions in this study are stated below:

1. The teacher is designated by society as the authority, or at least, the leader in the classroom. His behavior largely determines the affective and intellectual or cognitive climate of the classroom.

2. The major portion of the classroom behavior of teachers and pupils is directed towards the achievement of educational objectives.

3. The most direct and promising way to study teacher-pupil interaction is by systematic observation.

4. Systematic observation and analysis of teacher-pupil interaction can provide a sound empirical base on which a theory of teaching can be constructed.

5. The observation and tape-recording procedures do not result in significantly atypical classroom behavior.

6. A sufficiently large sample of the teacher's classroom behavior can be observed and recorded on magnetic tape so that the "record" is a representative sample of the teacher's classroom behavior.

7. The total observed classroom behavior can be classified into smaller (elemental) units and quantified.

8. Certain sequences and combinations of units can be observed to occur more frequently in some classrooms than in others. Furthermore, knowledge of the relative frequency of occurrence of various kinds of behavior is important to an understanding of classroom behavior.

9. The classroom behavior of teachers and pupils is multi-determined. Teacher and pupil attributes or characteristics, the subject matter and the particular course of study are considered to be the major determinants.

10. Teaching can be distinguished from learning and studied scientifically.

Limitations and Scope of the Study

1. This study is limited to high school biology lecture-discussion-recitation and laboratory classes of ten biology teachers. Field trips and class periods in which more than one third of the period was used for movies, silent study, seat work, and examinations or tests were excluded from the sample of four lecture and four laboratory classes per teacher.

2. Although this is a study of teacher-pupil interaction, in view of the complexity of the phenomenon, the major emphasis is placed on the classification of teacher behavior. Hence, all the verbal and certain (pedagogically relevant) non-verbal behaviors of teachers are categorized. Only a certain portion of the verbal behavior of pupils is categorized -- mainly questions and answers addressed to the teacher or the whole class. The non-verbal behavior of pupils is not categorized.

3. This study is an attempt at a description, but not an evaluation of biology teaching. The descriptive model of biology teaching is not considered to be representative of all or even most biology teachers, but is limited to the sample of this study. Further, the model is descriptive and not ideal or prescriptive.

4. A basic point of view in this study is that objective, quantitative description of teaching must precede the testing of hypotheses. Correlation and prediction from antecedents to intervening variables or from intervening variables to the consequents will not be attempted in this study.

Definition of Terms Used in the Study

Biology Class. A group, composed of a teacher and pupils, that meets in a classroom at a regularly scheduled time to pursue a New York State Regents Biology course or a Biological Sciences Curriculum Study (BSCS) course. This term includes lecture and laboratory classes.

Biology Classroom. This term is used in a general sense and refers to lecture rooms and laboratories in which pupils meet for instruction by a variety of methods such as lecture, discussion, recitation, demonstration and laboratory work under the direction of a teacher.

Categories are classes or divisions or compartments into which units of classroom behavior are classified. The limits or boundaries of each class are stated explicitly so as to include only certain kinds of behavior but not others.

Category System is a set of classes or compartments that are mutually exclusive or non-overlapping and that completely exhaust the specified domain of behavior to be classified. Further, the use of the word system means that the various components or categories are interrelated.

Classroom Behavior refers to what teachers and pupils say and do in the classroom during the scheduled class period and that is observable by another person (observer) with or without the aid of observational instruments or devices.

Interaction Analysis is a method that entails the following steps: (1) the use of a category system to obtain highly reliable, quantitative data of classroom behavior as it occurs, unit by unit, (2) a number of ways of summarizing the data in the form of frequencies, profiles and matrices (3) studying the inter-relationships of the various scores and

(4) describing the observed behavior.

Interaction Matrix is a systematic, rectangular arrangement of numbers in which the rows and columns represent categories of behavior. The cells, formed by the intersections of rows and columns, represent sequences of categories of behavior.

Laboratory Classes are instructional situations in which the pupils conduct experiments or carry on various learning activities requiring the manipulation of materials and apparatus according to a set of directions.

Lecture Classes. This term is used as an abbreviated name for instructional situations in which a variety of teaching methods are used. These methods are referred to by such names as lecture, discussion, recitation, lecture-demonstration, lecture-discussion, lecture-discussion-recitation etc. This term does not include laboratory classes. At times the term lecture classes is further shortened to "lectures."

Systematic Observation is the (relatively) unbiased recording of every unit of the observed behavior into one of the defined categories in a category system. The term unbiased means that all of the observed behavior is accounted for, not just the behavior which fits the observer's preconceptions of good or bad behavior (good or bad teaching).

Teacher-Pupil Interaction. This term is used in a restricted manner and refers to the observable reciprocal behaviors of teachers and pupils in classrooms during a regularly scheduled class period. The term classroom communication is used almost synonymously.

CHAPTER II

REVIEW OF LITERATURE

Related Research in Science Education

In much of the research on teaching -- and science teaching is no exception -- researchers have studied the antecedents and consequents of whatever it is that happens in classrooms. In a recent "inventory" of research in science education, Watson and Cooley (1960) found that most of the studies were one of three types: (1) "Status Studies," (2) "Methods Studies," (3) "Opinion Studies." In a more recent review Watson (1963 p. 1031) stated that "research on the relations between behavior of science teachers and other variables, such as behaviors of their pupils is meager." The writer's survey of literature related to science education revealed a similar lack of research devoted to the systematic study of classroom behavior of teachers and pupils. The existing research in science education is not directly related to the present study and hence will not be reviewed here. However, a number of surveys have been conducted to determine the various procedures and practices used by teachers in science laboratory classes. Typical of such studies are those by Anderson (1949), Cunningham (1946), Hawse (1957), Mark (1961), and Weckstein (1939). These studies are of some interest in that they give an indication of the great variety of practices and procedures used in science laboratory classes. The background or perspective gained from these studies enabled the writer to anticipate the variety and complexity of the situations in which laboratory instruction is carried on. These practices and procedures

are enumerated below:

1. Laboratory directions and instructions were given before or after class discussion of the laboratory activity.

2. Laboratory manuals were used or not used.

3. Laboratory classes were conducted with or without detailed instruction.

4. Laboratory demonstrations were presented by pupils or teacher.

5. Laboratory work was done by pupils individually or in small groups or teams of two to four pupils.

6. Pupils worked under "much" supervision by the teacher or under a "modicum" of supervision.

7. Pupils' laboratory work was given or assigned by the teacher versus laboratory work growing out of pupils' interest and initiative.

8. Pupils were required versus not required to write written reports of their laboratory work.

9. Pupils were required versus not required to take laboratory notes.

10. Pupils were required to make careful, detailed drawings or only brief, rough sketches.

11. The laboratory classes were scheduled once a week for a "single period" or a "double period."

In what specific ways do the above mentioned teaching practices affect teacher-pupil interaction and ultimately pupil learning? A suitable category system could be used to obtain quantitative information about the effects of various teaching practices on teacher-pupil interaction in laboratory classes. In the next section, the major studies related to systematic observation of classroom behavior are briefly reviewed. More comprehensive reviews can be found in the "Handbook of Research on Teaching" (Gage 1963).

Research on Systematic Observation of Classroom Behavior

The earliest systematic, observational studies of classroom interaction began with the work of Thomas et al. (1929), followed by Anderson (1939), Lewin and his associates, Lippit and White (1939), and Withall (1949). These studies showed that affective climate of the classroom is largely influenced, if not determined, by the teacher's behavior. They also stimulated a great deal of interest in systematic observation, description, and quantification of classroom behavior.

Thomas and her associates (1929) made a significant break from the traditional rating scales in use in her day and pioneered the development of objective systematic observation as a research technique for studying the behavior of nursery school children. The high standard of accuracy and objectivity set by Thomas contributed significantly to the establishment of systematic observation as a valuable technique in the study of social behavior.

Anderson (1939) developed over fifty highly specific categories to classify the behavior of teachers and pupils in pre-school and elementary classes. The categories of teacher behavior were subsumed under two major categories, viz., "dominative contacts" and "integrative contacts." He found that "dominative" teacher behavior provoked "dominative" behavior among pre-school and elementary school children and "integrative" teacher behavior facilitated "integrative" behavior among the children. Anderson calculated the "I-D Index" or ratio of "Integrative" to "Dominative" contacts.

Lewin, Lippitt and White (1939) studied the effects of "democratic," "laissez-faire" and "authoritarian" types of adult leadership on boys' groups. In general, their conclusion supported and extended Anderson's

conclusions and emphasized the tremendous influence exerted by the leader, not only in establishing group climate, but also on work production.

Withall (1949, 1951) renamed Anderson's dimension (the "I-D Index") as "Social-Emotional Climate" and focused on teacher behavior only. He developed seven categories for coding typescripts of teacher statements. These seven categories, such as "Learner-supportive" statements, "Acceptant" and Clarifying" statements, "Reproving" statements, were considered as lying on a continuum from "Learner-centeredness" to "Teacher-centeredness." Withall's "Climate Index" was compared with Anderson's "I-D Index" secured on the same data, and high agreement was found.

Hughes and her associates (1959) developed seven major categories within the framework of pedagogic functions, such as "Controlling Functions," "Facilitating Functions," "Functions that develop content," for describing elementary school teachers' behavior (pp. 59-61). Written protocols developed from shorthand notes were coded according to 31 functions subsumed under the seven large categories. A "model" pattern for teacher behavior was proposed, based on the analysis of the behavior of the 25 teachers "judged good" by administrative staff (Hughes et.al. 1959. p. 223).

Flanders (1962, 1963) greatly influenced by the work of Anderson (1939), Lewin et.al. (1939), and W.thall (1951), stressed the role of the teacher as an authority who influences the climate of the classroom directly or indirectly, i.e., dominatively or integratively. Flanders also introduced the concept of flexibility to account for the same teacher behaving dominatively or integratively under different situations. Flanders developed a system of seven categories for "teacher talk": "accepting feelings," "praising and encouraging," "accepting ideas" and "asking questions" were considered as "indirect influence" categories; "lecturing or giving information," "giving directions," "criticizing or

justifying authority" were regarded as "direct influence" categories. In addition, Flanders introduced two categories for classifying all of the "pupil-talk," viz., "pupil response" and "pupil initiation." By adding a category called "silence", Flanders developed a simple ten-category system for interaction analysis. A major (though understandable) shortcoming of the Flanders system is that most of his categories, especially the "content-categories," are much too global, e.g., "teacher asks questions" accounted for eight to fifteen percent and "lecturing" accounted twenty-five to fifty percent of the total verbal behavior of teachers (Amidon and Flanders 1963 p. 40). Amidon (Unpublished Mimeo), formerly associated with Flanders, attempted to rectify this shortcoming to some extent by dividing the category "teacher asks questions" into two categories, viz: "asks predictable-response question" and "asks unpredictable response question." Though Amidon has a total of seventeen categories in his revision, the category "lecturing" was not further sub-divided! Despite these shortcomings, Flanders has made major methodological contributions that are significant for the present study, viz., time-sampling every three seconds and tabulation of observational scores or tallies in a matrix. Medley and Mitzell (1963 p. 271) state that "Flanders has developed the most sophisticated technique for observing climate so far." In the same review Medley and Mitzell (1963 p. 274) referring to the 10 x 10 matrix state: "Flanders' scheme is extremely ingenious. Everyone of the 100 cells in the matrix of Fig. 1 [in the text] represents a different item of behavior with its own intrinsic interest. Yet the observer needs to learn and use only ten categories. The idea of categorizing the dominant pattern of a three-second period rather than each statement or other unit of behavior is also ingenious."

While the major emphasis in the above observational system is on the classification of the affective or social-emotional effects of teacher behavior, a distinct shift in emphasis toward the classification and description of the logical and cognitive aspects of classroom behavior can be seen in the work of Smith et.al. (1962 b.), Wright and Proctor (1962), Bellack and Davitz (1963) and Aschner (1963). Smith (1962 a.p. 326) persuasively advocating such a shift in emphasis warned that there was developing a tendency to view the social-emotional aspects of teaching as "more important than the cognitive -- at least as objects of study...it is well to remember that teaching consists not only in ways of relating to students but also in ways of dealing with the content of instruction." Theoretical concepts of logic, language and meaning, developed by philosophers and logicians and psychologists have been adapted for describing classroom discourse in the following studies.

Wright and Proctor (1962) conceived of three main categories of verbal interaction, "Content," "Process," and "Attitude," to distinguish between "high rigor" and "low rigor" teaching in high school mathematics. Each category is sub-divided into many categories, requiring considerable discrimination and mathematical sophistication on the part of the observer. A simplification would make it more useable. An interesting time sampling technique is used consisting of observing for 15 seconds, then writing for the next 15 seconds, and then observing for 15 seconds again, and so on.

Smith et.al. (1962 b.) developed an extremely detailed classification, consisting of twelve major categories and about twenty sub-categories, of the "logical operations" performed during teacher-student discussions in the four traditional subjects taught in the high school. The twelve major categories of logical operations are: "defining," "describing,"

"designating," "stating," "reporting," "substituting," "evaluating," "opining," "classifying," "comparing and contrasting," "conditional inferring," and "explaining." According to Smith et.al. (1960 b.p.4) "these operations exhibit a structure which can be observed and described... and evaluated logically by reference to rules of validity and correctness..."

Smith et.al. (1962 b.) have made a major and significant contribution to the description of the logical operations of teaching. Smith and co-workers restricted their research to the logical operations and did not develop a complete category system. The affective and procedural aspects of classroom behavior were not accounted for, and the verbal discourse was coded on the basis of the "ideal response" rather than the actual response (Smith et.al. 1962 b.p. 34). Smith and co-workers coded transcripts of tape-recordings, and considerable simplification would be needed for on-the-spot or "live" coding.

Bellack and Lavitz (1963) developed a system of content analysis for the study of linguistic behavior in classrooms. Borrowing the idea of a "language game" from Wittgenstein, the verbal discourse was classified into four types of "pedagogical moves," which are called "soliciting," "structuring," "responding" and "reacting" (p. 7). These four moves occur in cyclical patterns called "teaching cycles." Upon further analysis, Bellack and Davitz found four different kinds of meaning in the content of the messages, viz., "substantive meanings," "substantive-logical meanings," "instructional meanings" and "instructional-logical meanings." The logical operations were classified by Bellack and Davitz into: (1) Defining (denotative and connotative) and interpreting, (2) Fact stating and describing, (3) Explaining and (4) Evaluating (opining and justifying). The category system developed by Bellack and Davitz is far too complex to be used for on-the-spot coding, but two features of their work are of

considerable relevance to this study: (1) The introduction of multiple classification or coding of any unit of discourse (viz., a typewritten line) according to the pedagogical move, the topical content and logical operations of teaching; (2) The great simplification and reclassification of about thirty-three categories of logical operations developed by Smith et.al. (1962 b.) into seven categories.

An interesting coincidence is worth noting. The earliest work on the affective aspects of classrooms done by Anderson (1939) resulted in the development of over fifty categories to measure the "I-D Index." Withall (1949, 1951) simplified the measurement of the "Social-Emotional Climate" by using only seven categories. Similarly, the first attempts by Smith et.al. (1962 b.) at developing categories of logical operations of teaching resulted in about thirty-three categories. Bellack and Davitz (1963) simplified and reduced these to seven. In this study the logical operations are subsumed under four categories.

Aschner (1963) used a different approach and focused on the responses of gifted students to infer and classify the thought processes. Aschner's category system is based on Guilford's (1960) model of the "Structure of the Intellect." Aschner's five primary categories are: "Cognitive-Memory (C-M), Convergent Thinking (CT), Divergent Thinking (DT), Evaluative Thinking (ET)... and Routine" (Aschner 1963 p.59).

Summary of Research Reviewed

A number of points emerge from this somewhat historical review of the literature: (1) Thomas et.al. (1929) pioneered and helped establish systematic observation as a valuable research technique. (2) Anderson (1939), Lewin et.al. (1939), Withall (1949, 19[illegible] clearly demonstrated

the key position of the teacher or group leader in establishing the affective or social-emotional climate of the classroom with attendant effects on pupil-achievement, or work production. (3) Flanders (1962) in addition to developing a system of categories that included both pupil talk and teacher talk, introduced the idea of using matrices for analyzing teacher-pupil interaction. (4) Smith et.al. (1962 b.), Wright and Proctor (1961) departed from the traditional emphasis on social-emotional climate of the classroom and developed detailed categories of the logical operations of teaching. (5) Bellack and Davitz (1963) simplified Smith's classification scheme, but also used the idea of multiple coding of a given segment of behavior. (6) In general, the category systems emphasize either the affective or the cognitive aspects of classroom behavior.

Each researcher has profited from prior work and has added to our knowledge of both classroom behavior and techniques for research. A "new" researcher in this area can now draw upon an armamentarium of categories and techniques not available even five years ago.

In the writer's judgment, a highly desirable next step would be to develop one or more category systems containing a few well established major or global categories for the affective, cognitive and psychomotor dimensions of classroom behavior, as well as various levels and kinds of specific sub-categories. A given "specimen" of behavior recorded on tape or film, accompanied by typescripts and still photographs, could then be used for multiple-coding and analysis to provide different "levels" and kinds of information. Such analysis could be compared to the biologist or mineralogist examining a "specimen" for "field" characteristics nd also under a microscope at different levels of magnification, or undertaking a chemical analysis of the constituents. Certainly a "specimen" of classroom behavior is infinitely more rich in information, detail and pattern than any rock or plant or animal specimen.

CHAPTER III

DEVELOPMENT OF THE CATEGORY SYSTEM

Theoretical Considerations

While the major purpose of this research was to develop an observational method that would be useful in gathering data in biology classes, it must be borne in mind that empirical study and theory are inter-related. As Hollander and Hunt (1963 p.1) state: "The selection of a methodology depends, implicitly if not explicitly, upon the particular concepts which guide research in the first place."

At the very outset one must deal with the common misconception that a scientific study of the phenomenon of teaching is only a matter of seeking the facts of classroom life in an unbiased manner and objectively stating and describing what one observes. Rather, it must be recognized that scientific knowledge about the world is constructed by man and must be as reliable and as representative of the complexity of the phenomenon as possible. As Schwab (1960 p.178) states: "For the purposes of science, facts can no longer be treated as self-existing givens. They are matters contingent on the knower: on the operations he performs to bring them into view and on the conceptions which organize and control his operations."

In the ensuing pages, the writer will attempt to clearly state the notions and concepts that have guided the development of the category system reported in this study. In other words, the theoretical frame of reference will be made explicit.

Historically, ideas about education and the nature of man have long been the province of philosophers, and much of the history of education

is in a sense a history of philosophy. It has been in the relatively short period of the last two centuries that the content of the chapters in the book of educational history have been predominantly influenced by social scientists.

With the emergence of psychology and more recently sociology and anthropology as sciences, each claiming to study man and provide explanations of his behavior, educators found themselves choosing among competing concepts of personality, society and culture as <u>the</u> determinants of behavior. Even more recently, within the past fifty years, with the emergence of social-psychology as a science, attempts to systematically integrate the findings from various behavioral sciences have yielded more comprehensive concepts for our understanding of human behavior, and one such concept, viz., social interaction, is virtually at the crossroads of the behavioral sciences. As Hollander and Hunt (1963 p.255) so eloquently state: "Human interaction is a nucleus and 'Psychological, sociological, and anthropological manifestations all coalesce about it producing its particular colorations' .... Comprehension of the nature of social interaction is therefore a central task for social psychology."

The process of interaction can be viewed from a number of perspectives, and while it is generally recognized that interaction is multi-determined, different theorists give varying amounts of emphasis to the individual, social and cultural determinants of interaction. Setting aside the question of the relative effects of these determinants, interaction can be viewed as being an overt process, viz., communication, which can be observed and recorded by an observer, and a covert process, viz., perception, which can be inferred from the observed behavior.

From the viewpoint of the writer, at the very center of teaching, at least at the present time, is the classroom group, consisting of a teacher and pupils engaged in the process of social interaction directed toward the achievement of various purposes, especially the attainment of educational objectives. The description, prediction, and ultimately the control of classroom interaction is therefore the central task for the newly emerging science of teaching.

It is apparent from the immense complexity of teaching viewed as a special case of social interaction (Thelen 1963) that the problem of understanding the nature of teaching must be tackled in small steps. In the present study, restricted to high school biology teaching, the major focus will be on the observable communication-behavior of the teacher, and the secondary focus will be on pupil communication. The teacher is the leader, the authority in the classroom. However, to say that the teacher is the leader or authority in the classroom does not necessarily mean that the teacher is autocratic or authoritarian. As Getzels and Thelen (1960, p. 56) point out: "Indeed, even formally, authority can in fact be delegated for certain functions to the pupils, and frequently is. But such delegation cannot occur without the teacher's permission, given explicitly or implicitly."

To a large extent, the teacher influences not only the affective or social-emotional climate but also the cognitive or intellectual climate of the class. In the language of communication theory (Gerbner 1963) we can say that the teacher gives or sends information, whether solicited or unsolicited by pupils, and one or more pupils receive the information; when the teacher seeks or asks for information

one or more pupils give or send information. For instance, if the teacher asks for specific factual information, the pupils give or try to give specific factual information. If the teacher asks the student to explain, to formulate a hypothesis, to attempt a creative solution, the pupils (try to) respond accordingly. A pupil's performance may then be rewarded, accepted, corrected, ignored, etc. Furthermore, it is almost axiomatic that behavior is purposive, and one can assume that the major purpose or business of the classroom is the attainment of educational objectives, or as Getzels and Thelen (1960 p.54) have stated: "The classroom group comes together for the purpose of learning...despite the immediate and particular motives of the learners themselves."

The goals of education have been systematically classified by Bloom and associates (1954, 1964) into the well-known affective, cognitive, and psychomotor domains. Parenthetically, Bloom's "Taxonomy of Educational Objectives" has not been completed; the task of classifying the psychomotor domain remains to be done. In the category system developed in this study, the major emphasis is on the cognitive domain; but, the affective and psychomotor domain are also included. However, only those motor activities or non-verbal behavior of the teacher specifically relevant to the attainment of classroom goals are included and are classified in the procedural and cognitive domains. The writer's categories in the affective and cognitive dimensions bear some resemblance, but are not identical, to Bloom's categories. These domains or dimensions, though treated separately for analytical purposes, are really interpenetrating and inter-related.

The major concepts constituting the frame of reference can now be summarized as follows: Teaching is viewed as a special case of social interaction carried on via verbal and non-verbal communication. The two sources of communication in a classroom are the teacher and the pupil(s). By virtue of his position as a leader, the teacher has considerable control over the form and content of communication. Thus classroom communication is directed towards the achievement of affective, cognitive and psychomotor objectives.

Methodological Considerations

In addition to explicating one's theoretical frame of reference, a number of tactical decisions have to be made prior to and during the course of the development of a category system. The decisions made in this study and the supporting rationales are given below. The writer has drawn heavily from the works of Bales (1950), Berelson (1952), Heyns and Lippit (1954), Gellert (1955) and Hare (1960). The reader is urged to refer to the present category system while reading this section.

Subjects and Situations to be Observed

Eight science teachers teaching high school biology in eight secondary schools in central New York State were selected for observation. A search of the literature did not provide any definite answer to the problem of optimal sample size. In studies of a similar nature a wide range was found, i.e., Anderson's study (1939) was conducted with about six teachers, while the study by Bellack and Davitz (1963) was conducted with fifteen teachers.

Whether there is an optimum sample size for the development of a category system and the analysis of classroom interaction seems to

be more a matter of practical limitations of time, money, and facilities than any other criterion. In the sample chosen for this study, an attempt has been made to include as many as possible, but admittedly not all, of the factors that are thought to affect classroom interaction; the rationale being that the category systems developed from observations of a heterogenous group of teachers and learning situations would have fairly wide useability. Accordingly, within the limitations of time and resources available, cooperating teachers with the following characteristics were selected: The teachers were certified to teach Biology, they had two to twenty-five years of teaching experience and would be teaching the New York State Regents or the "new" BSCS Biology Courses. The researcher also made sure that single and double laboratory periods were included. It was also decided to select teachers from both rural and urban schools within a practicable commuting distance, namely a radius of about sixty miles from Ithaca, New York. There are over 100 schools in this area of Central New York, and data from the State Education Department were used to identify school districts with pupil enrollments ranging from approximately 500-15,000 (See Table 1).

It is not the researcher's intent in this developmental study to make broad unwarranted generalizations, or to infer statistical differentiation or calculate correlations between the above variables and the kinds of pupil-teacher interaction taking place in all biology classes and laboratories in New York State, or even Central New York.

TABLE 1 SELECTED CHARACTERISTICS OF TEACHERS AND SCHOOLS CO-OPERATING IN CATEGORY DEVELOPMENT PHASE OF THE STUDY

Characteristics	Teacher Number							
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8
Age as of 9/64	40	32	35	35	25	24	35	59
Sex	M	M	M	M	F	M	M	M
Total years teaching - 9/64	8	7	6	5	2	2	8	38
Years teaching other Sci. - 9/64	6	7	-	5	-	-	8	25
Years teaching Biol. - 9/64	2	5	6	4	2	2	6	25
Highest degree held	BS	BS	MS	BA	BS	BS	MS	MA
Additional credit hours	48	45	-	60	15	13	3	47
Undergraduate Major	Agri.	Bio.	Forestry	Agri.	Bio.	Bio.	Bio.	Bio.
Graduate Major	Agri.	Ed.	Zool.	Sci. Ed.	-	Bio.	G. Sci.	Phy. Ed.
Graduate Minor	Ed.	Bio.	Ed.	Bio.	-	Ed.	"	"
Credit hours in Biology	45	90	97	60	47	34	53	60
Credit hours in other Sci.	25	16	18	38	18	35	27	36
Credit hours in Math	0	0	6	0	0	6	6	16
Credit hours in Education	23	40	24	30	21	19	40	?
No. of In-Service Institutes	1	2	1	2	0	1	1	2

TABLE 1 (CONTINUED)

Characteristics	Teacher Number							
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8
No, of classes taught/day	4	4	4	4	4	4	4	2
Average class size	21	35	24	22	-	20	33	25
Length of class periods (Min.)	46	43	41	50	45	42	40	45
Type of class observed (Regents, BSCS, N.Y. Expt'l)	R	R	BSCS	NY Exp	R	R	R	R
No. of pupils in lect. observed	26	33	23	23	41	90	27	28
T's estimate of P's ability	Above Ave	Above Ave	Ave	Ave	Ave	Ave	Above Ave	Ave
No. of pupils in lab observed	12	9	24	23	20	30	27	8
T's estimate of P's ability	Above Ave	Ave	Below Ave	Ave	Ave	Below Ave	Above Ave	Ave
Size of School District	1600	1850	14,000	8200	1350	8000	3700	575
Pupils in grades 9-12	425	450	2950	2000	375	1600	900	225
Pupils in Sci. Grades 9-12	275	325	2075	1200	225	650	625	175
Sci. Teachers Grades 9-12	3	6	18	11	4	7	8	3
Annual per pupil Expenditure	575	500	600	1000	650	600	575	600

Frequency of Observations

Each teacher was visited once a month at regular intervals for four consecutive months from October to January in the Fall Term of 1964. One lecture class and one laboratory class was observed during each visit, except for a few cancellations due to unforseen circumstances. Each teacher was visited at monthly intervals rather than at daily, weekly, or fortnightly intervals on the assumption that greater differences in classroom behavior would probably be observed at monthly intervals as compared to more frequent visits.

Obtaining a Record of Classroom Behavior

The tremendous richness, complexity, rapidity and fleeting nature of classroom behavior precludes the commonly used technique of having an observer attempt to write down complete protocols and anecdotal records. On the other hand, the use of sound-film or video-tape would be an effective means of "capturing" the classroom behavior, but the expense involved was prohibitive. (Though technological developments will soon place video tape recorders within reach of researchers operating within modest budgets.) In this study a small, brief-case-sized, transistorized, portable tape recorder was used to capture the verbal communication and was supplemented by the observer's notes of non-verbal behavior devoted to the performance of pedagogical functions. A few tapes were transcribed, and the typescripts constituted a detailed written record of classroom verbal behavior. While this approach to "capturing" the classroom behavior worked quite well for lecture classes, except for the mumbling and softly spoken comments of pupils, the laboratory classes presented a difficult problem. Much of the teacher-pupil interaction in laboratory classes takes place at the pupils' laboratory desks at a very low decibel level, while the background noise is

usually high. The use of a tape recorder with a single microphone, no matter how strategically placed, proved to be quite unsatisfactory. The "problem" was solved by having the teacher wear on his belt, or place in a pocket, a small cigarette-pack-sized, wireless FM transmitter attached to a highly sensitive pen-type microphone. Teacher talk or even whispered conversation between the teacher and pupils was thus transmitted on radio frequency between 92-103 megacycles, and received via a small transistorized portable F.M. radio connected to the tape recorder. A set of earphones was also plugged into the radio so that the observer could monitor and categorize the teacher-pupil conversation while it was being recorded. Another advantage of using this technique was that the background noise was largely eliminated or reduced. This technique made it possible to hear and record a large amount of verbal interaction that would otherwise have been lost.

External Versus Internal Frame of Reference in Observation

An observer may classify behavior on the basis of an "internal" or an "external" frame of reference. In using the "internal" frame of reference, the observer is guided by the assumption that from the overt behavior one can reliably infer some internal unobservable aspect of the teacher ("actor"), such as his needs, attitudes, intentions, self-concepts, etc. Highly sophisticated and clinically trained observers are needed for coding, and in addition establishing the validity of such inferences would be a major problem. In using the "external" frame of reference the observer notes the effect of the actor's behavior on the "audience." This is done by the observer taking the role of the "generalized-other," and relatively little inference is required. It should be

noted, however, that while any two categories within a system, may be coded from the "external" frame of reference, the amount of inference required will probably vary. For example, very little inference is required in categorizing a given utterance as "a question" or "a directive," while a somewhat greater amount of inference may be called for in categorizing an utterance as "Teacher accepts feelings." Actually, it would be more accurate to say that these two frames of reference lie on two ends of a continuum.

In this study the observer used the "external frame" of reference, and asked himself the questions: What is the pedagogical function or operation being performed? What is the pedagogical effect of the behavior just emitted? While a relatively modest degree of observer sophistication is required, training is still necessary for an observer, not only for an understanding of the definitions of categories, but also for developing objectivity and not imputing his intentions and preconceived notions to either the "actor" or the "audience." The observer must be constantly aware of the crucial distinction between observation of behavior and evaluation of behavior.

Size of Unit of Behavior

Various units of behavior may be used for quantification, such as an act, a word, a sentence, a paragraph, an interaction, etc. Such units may be thought of as natural units. Behavior may also be quantified by imposing arbitrary units, such as a typewritten line or a time unit of a certain number of seconds or minutes.

A major problem in the use of natural units, such as sentences and paragraphs, is the great difficulty in deciding just when a sentence or paragraph begins or ends, especially while one is listening and

trying to categorize the interaction. This problem is alleviated considerably if a typescript is carefully prepared, but even then somewhat arbitrary decisions have to be made, e.g., should a compound sentence count as one sentence or two or three.

In this study the writer decided to use a time unit. The chief advantage of a time unit, especially for live or on-the-spot coding, is that the observer can develop a steady rhythm and be free to concentrate on the interaction. For the observer who cannot develop a steady rhythm or where a very high degree of accuracy is needed a simple mechanical or electronic aid, such as a watch, or flashing light, or buzzer could be provided. At the commencement of the study the writer used a three-second unit as described by Amidon and Flanders (1963). However, as the category system was being developed, considerable difficulty was experienced in using such a short time unit, and finally a five-second time unit was adopted. The length of the time unit depends to a large extent on the kind of discriminations that an observer has to make. If the categories are fairly general, few in number, and if very few and obvious cues or distinguishing characteristics are needed to classify a given segment of behavior, then the time units can be quite small. Flander's categories, such as "teacher asks questions," or "teacher gives directions,""teacher lectures" are examples of categories that can be coded fairly easily and rapidly. On the other hand, if one attempts to distinguish among various kinds of questions or directions, more skill and time are needed. In this study, the substantive information given or asked for was further classified according to the logical operations, viz., defining, fact stating, explaining, and evaluating. Frequently, questions or statements were

phrased in such a way that in the first two or three seconds it was impossible to categorize whether the speaker was stating a fact, explaining, or evaluating. Much less frequently, even a five-second interval was too short, and special rules were developed as stated in the ground rules of the category system in a subsequent section.

Another factor to be considered in deciding upon the length of the time unit is the rate at which changes or shifts occur in the kinds of behavior being observed. The more rapid the rate of change of behavior, the shorter the time unit must be, otherwise much of the subtleties of human interaction would be lost. Since some of the behavior in certain categories can and does occur in one second, or even less, such as a teacher saying "good," "OK," "yes," a ground rule has to be established so as to code the quick, short lived behaviors. Such a ground rule is used in this category system and stated under the ground rules of the category system.

Sampling an Entire Class Period Versus Part of a Period

In observing a class a decision must be made as to whether the behavior is to be categorized during the entire class period or during certain portion(s) of the period. Various sampling procedures are possible and can be conveniently thought of as being either continuous or intermittent. In the continuous sample some portion of the class period, such as the first half, the last half, or middle third, is categorized. In such cases the assumption is made that such a sample is representative of the behavior during the entire class period, or that it is most representative of the behavior the investigator is interested in studying. In the intermittent sample, the observer may categorize the interaction for a short time period, say five minutes,

then rest or take specific notes for a given number of minutes, then resume categorization and so on. If an observer is interested in pupil behavior, he may use a systematic rotation scheme to categorize individual pupils or groups of pupils for short periods of time.

In the writer's judgment our present knowledge of teacher-pupil interaction is so meager that it would be more desirable to categorize the entire class period provided it is not so fatiguing as to affect the observer's alertness.

In this study, the behavior was categorized for the entire duration of the class period, even at the risk of a certain amount of fatigue. The only exceptions were classes in which more than half of the period was used for a film, a test, silent reading, or student reports. A strong argument for this decision is that at this early stage of exploration the major purpose is the description of the phenomenon of teacher-pupil interaction in biology classes (with major focus on the teacher's behavior). Heyns and Lippit (1954) make a specially pertinent comment regarding sampling procedures: "It would seem desirable to make these procedures as all encompassing as possible at the outset and leave questions of sampling until we have more empirical data on the basis of which they can be settled definitively."

Effect of Observer on Classroom Behavior

What effect does an observer with a tape-recording device have on the behavior under observation? How typical or representative is the behavior and how valid is the information obtained in a study such as the present one? While the criticism implied in these questions has merit, it "...should not be taken too seriously " (Medley and Mitzel (1963 p.306). In a similar vein, Heyns and Lippit (1954 p.399)

sets of factors are easily discriminated. This multiplicative effect is used for other categories also, thereby increasing the number of categories and consequently the variety of information obtained while keeping the number of discriminations and level of inference relatively low.

Inter-relationships Among Categories

The categories in a given system may be discrete or continuous. In a system composed of continuous categories, the categories are arranged along some dimension so that a given category has more or less of a specific property than the one below or above it. According to Hayne and Lippit (1934, p. 121) very few category systems have continuous categories. So little is presently known about dimensional interaction that an attempt to develop continuous categories would be premature. Needless to say, the categories in this research system are discrete rather than continuous.

It should be fully recognized that the categories of the system constitute a nominal scale, and in the process of categorizing or scaling, equal weight is given to all behaviors subsumed under that category. For example, in a category, such as "teacher praises student" the remarks "that's a good interpretation" and "that's an excellent point" would both be scored as merely belonging to the given category. One may give that and disagree with the generalization underlying such a praise. The researcher's main interest is that in a large number of behaviors are scored, such discrepancies balance out. Psychologists may look at the fact that although the exact point scored in specific instances of the various kinds of teacher behaviors, such as praise, is not quite a valid

5. The observer took the opportunity to meet socially and formally with the teacher before or after a visit and discussed the project with the teachers, but without indicating the specific categories in the category system.

6. The teachers were asked to inform the pupils about the visit prior to the day of observation, and on the first visit the observer briefly explained the research project and the recording technique to the class. (The pupils were quite interested in the recording technique used in the laboratory including the use of a wireless FM transmitter).

It is the subjective impression of the writer that his presence had varying degrees of effect on the teachers and pupils. In terms of the question of observer effect it may be more important to say that the presence of an observer probably has a detrimental effect on classroom behavior, i.e., one may expect a teacher to behave more in accordance with "approved" techniques and procedures and less in relation to normal, if any this subjective evaluation of the observer effect does not appear to be particularly significant.

Limits of Video Taping

A given sequence of behavior may have more than one explanation or cause. Some researchers rely only the teaching situation, i.e., use a single cause, while others use a multiple cause. The choice depends on the purpose of the research. For instance, the cognitive and affective aspects of classroom interaction may be related to a pupil's response to light or sound

Multiple coding categories which are exhaustive and mutually exclusive would need to be done on a post-test or by placing a

recorded tape a number of times. In this study single coding was used and consequently any given unit of behavior was coded into one and only one category. In other words, the categories are mutually exclusive.

Quantification of a continuous stream of behavior into more or less arbitrary mutually-exclusive categories will seldom be completely satisfactory. Ideally, there should be minimal overlapping between categories, but no matter where the line of demarcation is drawn, there are always certain borderline behaviors that may be classified into one category or the other. In the final analysis, the judgment of the trained observer is the deciding factor. The reliability of the category system is checked by the ways taken to quantify the same and behavioral instances that must be obtained in order that [illegible] judgments are kept at a minimum.

Reliability of the Category System

A category system must meet the criterion of reliability, [illegible] the [illegible] of the system should [illegible], or describe [illegible] all the behaviors in the given category that are specified by the [illegible] of the category system. In spite of the [illegible] and variety of social interaction, it is conceivable to design a reasonably exhaustive category system which could be used [illegible] [illegible] [illegible]. However, research studies have dealt with natural behavior as it naturally occurs [illegible] the range of [illegible] of the categories. A more satisfactory method [illegible] would be simply having a category labelled "miscellaneous" in the system or "not classifiable in defined categories." The use

sence of such a category in a non-exhaustive system enables one to determine the proportion of total behavior not included in the system so that the scores can be studied meaningfully.

In this study an a priori decision was made to develop categories that would be exhaustive of all of the teacher's verbal behavior occurring in the classroom. Only those verbal behaviors of pupils which were solicited, permitted or recognized by the teacher were categorized. "Informal" pupil-pupil interaction was not categorized. Thus two major categories of pupil talk, viz., pupil seeks information and pupil gives information were formulated and subdivided. It was also recognized that an a priori decision would not be made to include all the non-verbal behavior occurring in classrooms. On the basis of the empirical work it was decided to classify only the major behavior of the teacher engaged in the performance of pedagogic interaction related to the cognitive and procedural domain as was typical in the category system. However, a category designated as 'non-identifiable in category system' was also included so that the comprehensiveness of the categories could be judged

The Number of Categories

Category systems vary widely in the number of categories they contain. Hough and Duncan (1970) reported that one might make any system that was developed as a hundred categories. Ultimately, the decision the number of categories, the reasons the difficulty involved in using the system and the reasons the amount of training required, also maximum reliability was to be achieved with a small number of mimeographed instructions. The exact number of categories in a system should be related to the development of a category system. The issue

tigator may make certain guesses and estimates and may attempt to have the smallest number of categories possible, but the final number of categories is dependent on the nature of the phenomenon and the amount and kind of information desired. However, it must be pointed out that, while the lay person may feel that it would be impossible to keep a large number of categories and criteria in mind, such a viewpoint is an underestimation of man's capacity. We respond to a myriad of stimuli and make the necessary discriminations in our everyday lives with such ease and rapidity that we are hardly aware of doing so. With a little training and practice the unfamiliar becomes familiar, and classification of behavior into a formal set of categories becomes almost automatic. This point has not been forcefully made in the literature and, unfortunately, a pot ial user of a category system is frightened away by a misconception regarding a large number of categories in a category system.

The sources of difficulty in using a category system lie primarily in the kinds of discriminations involved and the level of inference. In this study, specific attention was given to these factors rather than attempting to set an arbitrary maximum number of categories. There are about forty-five categories in the present system, but on [illegible] examination one can see a repetitive or multiplicative effect achieved by a combination of the following factors: two sources of communication (teacher and pupil), two ways of exchanging information (giving and seeking), and four logical operations or meanings (defining, describing, explaining and evaluating). Thus we have 2 x 2 x 4 or 16 categories, while training is needed only in discriminating among the four logical operations. It can be safely assumed that the first two

sets of factors are easily discriminated. This multiplicative effect is used for other categories also, thereby increasing the number of categories and consequently the variety of information obtained while keeping the number of discriminations and level of inference relatively low.

Inter-relationships Among Categories

The categories in a given system may be discrete or continuous. In a system composed of continuous categories, the categories are arranged along some dimension so that a given category has more or less of a specific property than the one below or above it. According to Wayne and Lipsit (1934, p. 173) very few category systems have entirely discrete categories. As little is presently known about significant interaction that an attempt to develop continuous categories would be premature. Needless to say, the categories in the present system are discrete rather than continuous.

It should be fully recognized that the categories of the system constitute a nominal scale, and in the process of categorizing an analyst might be given an additional number which purports to represent the position of the category in relation to other categories, such as ranking, but no order is assigned to such

Amount of Behavioral Context Used in Coding

A persistent source of observer disagreement in coding a given behavior is the amount of context to be kept in mind when coding. The smaller the amount of context to be kept in mind, the smaller the demands on the observer to remember past behavior and simultaneously observe on-going behavior and thereby the greater the reliability of coding.

In the present category system the observer categorizes a five-second (or less) segment of behavior immediately preceding the writing down of the category number.

Limited Versus Wide Applicability

A category system can be developed for use in fairly specific situations or a wide variety of situations, depending on the purpose of the research and the nature of the phenomenon being classified. For instance, Flanders' category system is being used or tried out on all grade levels in most school subjects, and even in non-classroom situations, while the category system developed by Weights and Pounds (1961) is restricted to use in mathematics classes.

On the basis of a review of the literature and also to some extent practical limitations of time and money, the present study was restricted to the development of a category system for use in history lessons and history classes. In the writer's opinion, estimating the applicability of such a category system to other content subjects will probably entail relatively minor changes.

Validity of a Category System

Psychometricians have long struggled with the controversial num-

cept of validity, and it is now generally accepted that the term has a variety of meanings. Four kinds of validity of a measuring instrument are generally recognized, viz., Content or Face validity, Concept or Construct validity, Predictive validity and Concurrent validity. Further, the purpose for which a measuring instrument is used has considerable bearing on the kind of validity that is most important.

Typically, in observer systems the problem of validity is largely ignored and a question is raised about the appropriateness of the application of the psychometrician's concepts of validity to observer systems. The question of validity of an observer system is most often dealt with by "arguing face validity" (Lambert 1964). For categories requiring very little inference, where the observer uses the "natural" frame of reference, as is the case in the present study, there would be little question about face validity. This point is made succinctly by Hayes and Lipsitz (1968, p. 398): "No one seriously doubts that the answer to the category 'make question' corresponds what is to supposed to represent, least of all the people using the system."

Another way of establishing validity is often suggested, i.e., to compare the instrument scores obtained by using another category system that purports to quantify the same aspects of behavior. However, two problems are immediately encountered. First, there is little likelihood of finding a "comparable" category system. Second, even if a comparison could be made, what high agreements would demonstrate can't a multiplicity, but two agreements could not be considered as an invalidation. The question would arise as to the validity of the criterion and whether it really measured the same aspects of behavior (Medley 1972, p. 1881 Moreover, it should be borne in mind that the name of a category is essentially a subjective definition and the development of category

systems has considerable latitude in stipulating the name (and number) for a certain class of behaviors. It is far more important that the behaviors be unambiguously specified.

While the question of face validity is relevant for description of behavior, the predictive validity is important when one wishes to use the category system for the purpose of prediction, e.g., to predict some aspect of pupil performance from certain kinds of classroom behavior. Since the purpose of this study is restricted to the description of classroom behavior, further consideration of the question of validity is beyond the scope of the present research.

The Reliability of a Category System

One of the most outstanding features of category systems as observational tools is that objective information can be obtained. Two or more observers categorizing the behavior in a given class at the same time can obtain essentially the same data. The term reliability has a number of meanings, and in this study the term is used in relation to observer agreement. Hunt's modification of reliability terms (1961) as discussed by Amidon and Flanders (1963) has been used to assess the reliability of the present system. In general, reliability coefficients of .75 or more were obtained. Detailed information about the reliability used in given for another system.

The many mathematical manipulations discussed in this section are intimately related and affect the reliability of the category system. Thus the development of a category system requires careful weighing and balancing of these factors. Medley (1959, p. 185-186) has summarized the many sources of poor reliability found in observational instruments as follows: "... It includes sampling if there is presumption in defining

behavior 3) Complexity of method of recording 4) Rapid, complex interaction 5) Difference in perspective of observers 6) Individual differences in degree of decisiveness of activities of subjects observed 7) Constant errors due to observer bias (overweighting, aiming, "halo" effects, etc.) 8) Requiring high order inferences in classifying behavior 9) Demanding the simultaneous observation of too many variables 10) Excessively long periods of observation without interspersed rest periods 11) Inadequate training of observers 12) The effect of individual observers upon the behavior of the subjects 13) Degree of acquaintance with the subjects."

In our present state of knowledge, the development of a category system is probably as much an art as it is a science. While attempting to continue the tradition of high reliability of category systems, the present writer is in agreement with Smith's point of view that one can be so concerned with securing high coefficients of reliability, that there is a danger of selecting only those categories which can be used with high reliability and in the process "...sacrifice intimate personal contact with the more vital parts of our problem..." (Smith [64] p. p. 161)

The Formulation of Categories

The writer has discussed the many decisions that must be made and how these decisions can affect the many properties of a category system. One may conventionally think of them as a set of specifications governing the construction of an observational instrument. While a number of these decisions are made prior to the "field work" of observation in the natural behavior setting, the end result of category system is a product of a complex interplay of theoretical and methodological considerations and empirical findings. It is in the process of "wrestling and grappling" with elusive behaviors that one finally comes to grips with

the problem. It is this experience of reaching for the substance and finding the shadow alternating with the excitement and exhilaration of seeing an underlying unity and pattern in the bewilderingly complex and rapidly changing panorama that constitutes the very essence of the procedure of developing a system to classify teacher behavior and teacher-pupil interaction. A more "objective" statement of the procedure used in developing the category system is given in the following paragraphs.

The reader may recall that during the category development phase of this study, each of the eight teachers were visited once a month for the span of two teaching days for four successive months beginning October, 1964. During each visit, the classroom discourse for the entire duration of each lecture and laboratory class was recorded on magnetic tape, as described previously. In addition, the observer took notes on the teacher's verbal and non-verbal behavior, and especially, noted non-verbal behaviors thought to have significant relevance, for example, if students looked through classrooms, I drew how it was fire extinguishers, I discriminate questions, I prepare questions, I make unusual, I write on desk and looks at clocks, I draws diagrams, I spoil make a big noise, I move to don't see anything on the walls, I ask the high discussion, I make pupils how they are doing, I hands and the classroom, I gives instructions, I gives reassurance, I gives encouragement and does not disturb it, I writes on board, I make some move finished the teaching, etc. [These notes supplemented the tape and recording system of the classroom discussion proposed by the actual recordings.]

The notes were especially critical since the tapes were to pick up only the verbal. Eventually seven categories were used to [illegible] behavior, and 'caught and recorded'

names were given. Almost immediately borderline cases were encountered and gradually more precise distinguishing criteria were formulated. These tentative or trial categories were then used or tried for on-the-spot coding and modified, revised, or rejected in subsequent visits. It is precisely this constant interplay of empirical data with the explicit and implicit theoretical framework that further develops and explicates the theoretical framework on the one hand and sensitizes the observation process on the other. By repeating this cyclical process many times, the category system in its present form was developed.

Description of the Category System

The category system developed in this study has sixteen major categories, designated by numbers one to sixteen, and twenty-eight sub-categories, designated by a combination of a number and a letter. The main categories, when used without the modifier, refers to both the major categories and the sub-categories. The present category system has sufficient major categories for classifying teacher behavior, but major categories may sometimes fail, and the ability or power to communicate and a rational category, irrespective of the importance in use of the above categories. While reading this section it would be extremely useful to refer to the outline of the category system in the back of the report.

The sixteen major categories or teacher behavior are divided into three major dimensions, namely, evaluative, cognitive and procedural dimensions. The major dimensions are composed of sub-dimensions, such as "information giving" and "information seeking." The sub-dimensions are in turn composed of major categories, and certain major categories are split into sub-categories.

Evaluative Dimension (Affective-Substantive)

The dominant feature of the Evaluative Dimension is the effect of the teacher's behavior on the affective or social-emotional climate of the classroom. However, this is a mixed dimension, since all statements made by the teacher and having the effect of evaluating either the pupil's social conduct or his cognitive-task-behavior are classified into one of the four major categories in the Evaluative Dimension. Category one, teacher praises; and category four, teacher reprimands; constitute the "positive" and "negative" ends of a continuum. These categories are most closely related to the affective climate of the classroom. Category two, teacher accepts pupil's substantive contributions; and category three, teacher corrects pupil's substantive contributions; constitutes the "neutral" or task related area between the two ends of the continuum.

The effects of the above mentioned evaluative statements are highly interrelated, but for analytical purposes these statements are classified separately. The values are listed for the various categories.

[illegible]

[illegible] the dominant concern of classroom evaluation and also in the [illegible] of classroom [illegible] that calls the "cognitive domain," and some of the categories in this area are derived [illegible] of the cognitive or intellectual behavior of learning and problem [illegible] The basic [illegible] categories refers to the organization of data, concepts and principles. Such a statement is one example. If the instructional goals of Miss Sam's mind works and [illegible] by this author, i.e., the "intellectual discipline" of the learner. The cognitive evaluation of learning products [illegible] the complex domain of a curriculum..."

Two sub-dimensions of the Cognitive Dimension are "Substantive Information-Giving" and "Substantive Information-Seeking." Substantive information, or in this case, the subject matter of Biology, is composed of both "product" and "process." The "product" refers to the facts, concepts, principles, theories, etc. of Biology, while the "process" refers to the scientific processes and methods that generate the "product." Here again process and product are inter-related, but are separated for analytical purposes.

Cognitive or substantive information is primarily communicated or exchanged verbally by logical or quasi-logical processes in most of the traditional school subjects. However, in science, demonstration of phenomena, manipulation of apparatus (category five) and visual observation aided or unaided by instruments (category nine) constitute important non-verbal modes of giving and seeking information. Accordingly, the substantive information-giving and information-seeking behavior is further classified into verbal and non-verbal behavior. The verbal discourse in the cognitive domain is still further classified according to the criterion of logicality, as "logical" e.g., categories 6D, 6F, 6X, 6E and "extra-logical," e.g., categories 7, 7C, 7S. However, according to modern linguistic conceptions of language, what a person does with language and how he uses it over-rides strictly formal and logical properties, as Hockett (1958, p. 7) cogently states: "From the linguistic point of view, the "logical" approach to language is too narrow." Hence, in the present category system Defining, Fact stating, Explaining and Evaluating are viewed as quasi-logical operations rather than formal or "ideal" logical operations, as viewed by Smith et. al. (1962 b.) and Bellack and Davitz (1963). In brief, the criterion can be illustrated as follows: if the effect of the speaker's words is to give the meaning

Definitions of Categories

Category 1. Teacher Praises, Encourages, Jokes, Reduces Tension, Accepts Feelings. The teacher praises, rewards, acknowledges the contributions and efforts of the pupils. The tone of voice usually conveys pleasure, satisfaction, or positive evaluation. Often a single word or phrase is used with accentuation rather than a matter of fact tone of voice, e.g., right; good; exactly; that is a good slide. The teacher encourages the student to continue or pursue an idea further, e.g., go on; what else; ...yes...yes...; and; anymore; uh, huh; I think you've almost finished the dissection, keep going. This category also includes jokes, humor that is not at the expense of pupils, and statements that help to reduce tension or anxiety. The teacher accepts and understands the pupil's feelings of confusion, frustration, anger, boredom, joy, satisfaction, pleasure, e.g., I know this is pretty hard to understand at first; you look puzzled, let's go over this again; I think I know how you feel; that's pretty interesting, isn't it? Also included in this category are questions or comments expressing interest or concern in the pupil's personal health or progress in school: Is your shoulder ok now? How are you doing in your other subjects?

Category 2. Teacher Accepts Pupil's Ideas, Contributions, Work. The teacher repeats a pupil's answer in part, in summary or in full, with or without minor rephrasing. The teacher states in a neutral or matter of fact tone of voice that the response is correct, or that the pupil's ideas or suggestions are useful or worth taking into account, e.g., that's an interesting idea; that's another point; that slide is ok; yes; correct; right. [The teacher does not qualify, or correct the pupil's response. The observer must be alert to quick shifts from category two to category one or three].

ever, the pupils' behavior (at least, that observed during the category development phase of this study) differed notably from the teacher-behavior in the following respects: (1) Pupils seldom, if ever, overtly evaluated the teacher's behavior in the classroom--i.e., few or no parallels to categories one, two, three and four. (2) Pupils seldom gave demonstrations, laboratory directions, procedural directives, and seldom examined, corrected, or supervised the work of other pupils--i.e., few or no parallels to categories five, seven, nine, eleven, twelve and thirteen. In view of the above exceptions, and since the emphasis in this study is primarily on teacher behavior, the writer decided to allot the smallest number of categories to pupils' verbal behavior, without significant loss of detail and information. Hence, only one "dimension", consisting of two major categories, is used to classify the verbal behavior of pupils. Admittedly, "Pupil-Talk" is a mixed dimension since the "Substantive" information giving and seeking as well as "Procedural" information giving and seeking behaviors are included in a single dimension. The reader will note that the pupils' substantive information-giving are subdivided according to the same criteria of "logical" and "extra-logical" operations used earlier in the classification of teacher's behavior. By using this procedure the "memory-load" and the numbers and kinds of discriminations is kept to a minimum. In effect, fourteen subcategories of the pupils' verbal behavior are classified under two major categories.

Silence

This category is used only for short pauses in communication during teacher-pupil interaction and is not used for classifying nonverbal behavior specified in other categories.

Not Categorizeable in the Category System

The presence of this "residual category" is important in determining the exhaustiveness of the system, especially, during the development of a category system. Such a category may become less important, or at least have decreasing use, after the initial trials and revisions of a category system. This category is used for behaviors that cannot be classified or categorized into any of the other categories in the system.

OUTLINE OF CATEGORY SYSTEM FOR INTERACTION ANALYSIS IN BIOLOGY CLASSES

EVALUATIVE DIMENSION (AFFECTIVE - SUBSTANTIVE)

"Positive" Affective Evaluation

1 T Praises, Encourages, Jokes, Reduces Tension, Accepts Feelings

Evaluation of Substantive Responses

2 T Accepts Pupil's Substantive Responses or Work, and Contributions

3 T Qualifies, Corrects Pupil's Substantive Responses, Work, and and Contributions

"Negative" Affective Evaluation

4 T Reprimands Pupil for Misbehavior, Uses Sarcasm, Shouts, Threatens

COGNITIVE DIMENSION

Substantive Information Giving

Non-Verbal

5 T Gives Demonstration of Technique, Process, Phenomenon, etc.

Verbal

6 T Gives Substantive Information

6D T Defines Terms, Gives Examples of Terms

6F T States Facts, Describes, Gives an Account or Report of an Event

6X T Explains, Makes Inferences, Makes Comparisons, States Relationships between Objects, Events, Generalizations

6E T Evaluates, Makes Value Judgment, Gives Opinions about the Subject Matter

6N T Gives Information about the Nature of Science

6L T Makes Statements about Lack of Information and Limitation of Knowledge

7 T Gives Laboratory and Substantive Directions

7C T States Precautions or Requires Strict Adherence to Certain Steps in the Procedure to be Followed

7S T Suggests or Allows Alternative or New Approaches to an Experiment, Activity or Problem

Substantive Information Seeking

Verbal

8 T Asks Questions

8D T Asks Pupil to Define Terms, Give Examples of Terms

8F T Asks Pupil to State Facts, Describe, Give an Account or Report of an Event

8X T Asks Pupil to Explain, Make Inferences, Make Comparisons, State Relationships between Objects, Events, Generalizations

8E T Asks Pupil to Evaluate, Make Value Judgment, Give Opinions about the Subject Matter

8N T Asks Pupil to Give Information about the Nature of Science

8P T Asks about Problem Solving Procedures, Techniques, Steps to be taken to carry out experiment, or to solve a problem that grows out of, or is an extension of the "required" work

Non-Verbal

9 T Examines, Checks, Looks at, Pupil's Work

PROCEDURAL DIMENSION

Verbal

Seeking Procedural Information

10 T Asks Questions regarding Class Routines, Assignments, Procedures, Materials, T Asks if Pupils Understand, Need Help, Clarification, Repetition

Giving Procedural Information

11 T Gives Routine Directives, Gives Assignments, Gives Procedural Orientation, Explicates Transition of Topics

Non-Verbal

Performance of Routines and Services

12 T Attends to Routines and Class-Management, Distributes Materials, Prepares Materials, Performs Services, Takes Attendance, Marks Papers, Consults Notes and References

Minimal Interaction

13 T Oversees or Supervises Pupils at Work, Walks around, Stands or Sits at his desk or some other part of the room and watches pupils doing seat work or laboratory work

PUPIL TALK DIMENSION

14 P Asks for Substantive Information and Assistance

Substantive Information Seeking

14D; 14F; 14X; 14E; 14N (See Category 8.)

Procedural Information Seeking

14A P Seeks Assistance, Asks About Directions, Procedures, Techniques, Materials, Routines

15 P Gives Information or Responds

Substantive Information Giving

15D; 15F; 15X; 15E; 15N; 15L (See Category 6.)

15P P States, Describes, Explains, Proposes the steps he will or would take in order to solve the problem or carry out an experiment that grows out of or is an extension of the "required" work

Procedural Information Giving

15R P Gives Information Regarding Assignments, Classroom Procedures and Routines

SILENCE

16 Short Silent Periods especially after questions by teacher or pupil, or after directives that are to be complied with immediately. Also included are silent pauses four seconds or longer in the middle of a sentence or between sentences. Shift to the appropriate category, 9, 12 or 13, when pupils are engaged in seat work or laboratory work or for periods of silence longer than 30 seconds.

NOT CATEGORIZABLE

17 Not Categorizable in Above System. The observed behavior cannot be classified into any of the above categories.

Procedure for Categorizing Teacher-Pupil Interaction

1. The observer should be seated and ready to start coding or categorizing before the class begins. By prior arrangement with the teacher the observer should select a seat in the back or at the side of the room such that the observer is as unobtrusive as possible while still in a position to clearly see and hear the classroom interaction.
2. The observer starts categorizing as soon as the bell or buzzer sounds or the teacher starts the class, whichever comes first, and continues categorizing until the teacher dismisses or excuses the class, or the class leaves at the sound of the bell or buzzer.
3. Keeping as steady a tempo as possible, every five seconds the observer writes down one and only one category number to classify the interaction just observed in the preceding five seconds. The category numbers are recorded in sequence in rows. If a "shift" or change in interaction category occurs in less than five seconds the observer records all such shifts, for instance, teacher question--student response--teacher evaluation of response, may occur in rapid succession. If no "shift" or change occurs repeat that category number at the end of the next five seconds.
4. The observer writes 16, the category number for "silence", at the beginning and end of each period of observation so that the row and column totals in the matrix will be the same. Sixteen is selected somewhat arbitrarily.
5. The observer does not categorize the following kinds of behavior:
   a) Pupil raises hand requesting permission to ask a question or give an answer.

b) Pupil calls the teacher's name in order to ask a question or give an answer.

c) Teacher nods, points to, or calls a pupil by name or otherwise indicates permission to speak in response to pupil's upraised hand or call.

d) Interruption of "regular" class work is noted in the margins, e.g., announcements over the public address system, telephone calls, messengers or other visitors talking to the teacher, special announcements read or made by teacher which are clearly not a part of the regular classroom routines and procedures. The observer writes the time elapsed or puts a dot every five seconds to account for the time elapsed, e.g., /P.A. announcement 23 secs./ or /Telephone ..../. At the end of the "interruption" the observer resumes categorization.

e) Teacher mumbles or talks to himself, e.g., while looking for supplies, looking through his notes, or while examining a pupil's work.

6. The observer writes brief notes in the margin, describing the kind of class activity or matters of interest to the observer.

7. The observer categorizes from the perspective of the "generalized other." Only the observed classroom communication is categorized according to the effect it has on the observer as he takes the role of the "generalized other." The observer should constantly be on guard against categorizing on the basis of his own biases or inferences regarding the teacher's or pupil's intentions and deep seated psychological motivations. To repeat--only the overt and observable behaviors are categorized.

Definitions of Categories

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Category 3. Teacher Modifies, Qualifies or Corrects Pupil's Substantive Responses, Contributions or Work. This category is restricted to substantive or subject matter related statements, responses, and contributions made by the pupils. Reprimanding, scolding, correcting misbehavior are not included in this category but rather in category four. The tone of voice is usually business-like or matter of fact. The teacher's statements ranging from slight qualification to complete rejection or correction are included, e.g., almost, but not quite...; that's generally true, but not in this case...; no, that's an artery, not a vein. Sometimes the teacher "corrects" the pupil's response by asking a question; Is that a genotype? Is that a hormone? Are you sure you used 5cc of Fehling's solution?

Category 4. Teacher Reprimands Pupil (s) for Misbehavior, Uses Sarcasm, Shouts, Threatens, Complains. Teacher corrects pupil's misbehavior, scolds, shouts, uses sarcasm, tells student to change his seat, to leave the classroom, deflates pupil's status, expresses displeasure at students' behavior. Teacher justifies or defends his authority, e.g., Bill! just once more and I'll send you out; that's a bright thing to do; sit down; stop talking; I don't know how I'm going to get any work out of you; I told you not to fool around with the bunsen burner; Why don't you pay attention?

Category 5. Teacher Gives Demonstration of Techniques, Process, Phenomenon, etc. Teacher shows (by actual manipulation) how apparatus is to be set up, or used. Teacher actually carries out some laboratory activity, such as using the microscope or dissecting, using chemicals, anesthetizing a frog, etc. Teacher may "demonstrate" (or show how) at pupil's laboratory desk or in front of whole class silently or along with

questions, directions, explanations, etc. Categorize both the non-verbal and verbal, e.g., you take an eye dropper and add the reagent drop by drop by drop like so and...; you hold the test-tube pointed away from you, like this, and...; watch carefully as I add this; why did it burn? The use of visual aids such as diagrams, charts, slides, models, etc. are not included in this category.

Category 6. Teacher Gives Substantive Information. The teacher defines terms, gives names of objects, states facts, laws, theories, describes objects, processes, gives explanations, reasons, relationships, engages in inductive or deductive reasoning, makes value judgments, gives opinions, gives information about the nature of science, states that he or scientists lack certain knowledge. Note: The word "object" is used to include non-living things as well as organisms or parts of organisms, and the word "information" is used rather broadly to include definitions, facts, explanations etc. Where applicable the following sub-divisions or sub-categories are used, viz., 6D, 6F, 6X, 6E, 6N, 6L. The designation 6U is used to indicate that the "information" cannot be classified or categorized in one of the sub-categories of "6."

Sub-Category 6D. Teacher Defines Terms, Gives Examples of Terms. Teachers convey meanings of terms in many ways, such as the following:

1) By giving examples of terms, e.g., legumes are plants like clover, peas, alfalfa, and so on; the heart, the stomach, the lungs, the liver, and so on -- these are all examples of organs; another kind (type or example) of asexual reproduction is budding.

2) By pointing to the object, model, diagram, picture, etc., e.g., this is a burette; this is the eye piece; here's the anther.

3) By using symbols, synonyms, expressions having similar meaning, e.g., carbon is C; sucrose or cane sugar; DNA or deoxyribonucleic acid.

4) By giving the genus or class term and differentia (classificatory definition) e.g., an artery is a blood vessel that carries blood away from the heart. The genus or class term is "blood vessel," and "carries blood away from the heart" is the differentia. The differentia may be functions, processes, qualities or properties or attributes, e.g., the ventricles are the thickest chambers of the heart; the ventricles are the pumping chambers of the heart; the biceps are the muscles that bend the arm. Note: The distinction between a classificatory definition and description of an organism or object is often subtle and difficult to make since teachers may actually make a short descriptive statement as a way of "defining" or add a descriptive statement to the differentia. Contextual clues need to be used in deciding which category to use. Strictly speaking, to define is to give only the defining or essential characteristics. A word is said to be defined completely when all the essential characteristics are stated, however, teachers may give incomplete definitions or give a few of the defining characteristics at a time. Also, teachers may give associated as well as common or shared characteristics to convey the meaning of the term, e.g., vitamins are chemicals that are needed by the body to maintain good health.[So are many other chemicals.]

Hence, in deciding whether to use Category 6D or 6F, the observer should judge on the basis of contextual clues whether or not the teacher is trying to develop the vocabulary and terminology or is giving factual or descriptive information. When in doubt between 6D and 6F, use 6D on the assumption that this is the "meaning" the pupil is given, at least for the time being.

Sub-Category 6F. Teacher States Facts, Describes, Gives an Account or Report of an Event. Teacher states facts without explaining or giving relationships between facts, gives an account or report of a past or presently occurring event, situation or state of affairs. Teacher describes an object by stating its attributes, functions, structure, uses, etc. A statement need not be an isolated bit of information to be coded in this category. Teachers may state generalizations as important information to be memorized by pupils. Teachers give factual information in many ways, such as the following:

1) Teacher states what happened or is happening, e.g., millions of people died (or are dying) from malaria; the green plant gives off oxygen.

2) Teacher states what was done or is being done, e.g., Robert Hooke looked at a piece of cork under the microscope; scientists are trying to find what causes cancer.

3) Teacher states the functions, purposes, uses, structure, shape, composition, properties or attributes, location of an object, e.g., the function (purpose) of the cilia is to help the paramecium to move; the cilia are used for locomotion in the paramecium; the long bones are made up of marrow, blood vessels, bony layer...; another property of the arteries is that they are quite elastic; the cells of the epidermis are brick shaped; the adrenal glands are located above the kidneys.

4) Teacher states numerical values, how many, how much, what size, etc., of some object, e.g., your body contains about 12 pints of blood; the heart beats about 70 times per minute; the heart is about the size of your fist; bacteria divide about every 30 minutes.

5) Teacher makes statements regarding the existence (or lack) of an object, etc., e.g., the Dodo bird is extinct; kangaroos are found in

Australia; the nerve endings for touch are located close to the surface of the skin.

6) Teacher states something that the pupils have experienced, e.g., you saw the three-chambered heart when you dissected a frog.

7) Teacher states the observations, data, result of an experiment, laboratory or class activity, or demonstration.

Sub-Category 6X. Teacher Explains, Makes Inferences, Makes Comparisons, States Relationships between Objects, Events, Generalizations. Teachers explain in many ways such as the following:

1) Teacher states the relationship between antecedent and consequent, or cause and effect, and makes inferences, e.g., due to an over secretion of the thyroid hormone, the metabolism is speeded up and...; if the diet is deficient in Vitamin A, then...; the nucleus appears darker because it absorbs more iodine than the rest of the cell. Verbal cues, such as because, due to, therefore, the reason, since, if...then, are very useful in identifying explanations and inferences.

2) Teacher shows relationship by explicitly comparing and contrasting, i.e., by stating the similarities and differences, e.g., the heart of amphibians is three-chambered, whereas that of mammals is four-chambered. Verbal cues, such as differ, compare, correspond, like, similar, common, are useful in identifying comparisons.

3) Teacher states the relationship between or among events, functions, objects, concepts, generalizations, e.g., as the left ventricle contracts, the aortic valve opens and...; as the oxygen supply decreases the number of anaerobic bacteria begins to increase...; the function of the left ventricle is to pump blood to the body, and so you would expect the muscles to be thicker than....

4) Teacher gives justification or states reasons for an opinion, evaluation, laboratory precaution, e.g., the stomach is not as important an organ as one may think because one can survive even when it is removed; the pituitary is probably the most important endocrine gland because it has an effect on so many other glands.

5) Teacher states the steps in a process or procedure, such as cell division, digestion, breathing, removal of oxygen from the blood. Sub-category 6X rather than 6F is used, since the individual steps are not isolated bits of information, but are interconnected and often follow a certain sequence as indicated by verbal cues, such as: to start with, first, next, then, from there it goes to. Note that though laboratory directions often include procedural explanations, the directions are coded as category seven and not 6X.

Sub-Category 6E. Teacher Evaluates, Makes Value Judgment, Gives Opinions about the Subject Matter. The teacher gives an evaluation or opinions regarding the importance, value of an object, biological function, attribute, process, event, generalization, e.g., the stomach is not as important or necessary as one may think; I think that both heredity and environment are important in determining the personality; the process of mutation is important in producing variations. Recall that justification or reason for the evaluation or opinion would be categorized as 6X. Note: This sub-category does not include evaluation of pupil's responses and behavior or misbehavior.

Sub-Category 6N. Teacher Gives Information about the Nature of Science. A universally acceptable, definitive statement about "The Nature of Science" is not possible. "Information about the Nature of Science" will be used in a broad general sense to include statements about science as organized knowledge and as processes of inquiry.

The teacher gives information about:

1) the inter-relatedness of scientific knowledge and scientific disciplines;

2) the processes and role (in science) of observation, inference, classification, verification, analysis, speculation, prediction, experimentation, communication, generalization, conceptual schemes, theories, principles, laws, hypotheses, etc.

3) scientific attitudes, such as objectivity, open-mindedness, belief in cause and effect, curiosity, patience, dedication, etc.

Sub-Category 6L. Teacher Makes Statements about Lack of Information and Limitation of Knowledge. Teacher states that he doesn't know, he is not sure, he will "look up" the information, or that probably scientists do not know. For example, after looking at some object on a pupil's slide the teacher may say: I don't know what that is.

Category 7. Teacher Gives Laboratory and Substantive Instructions or Directions. Teacher gives laboratory directions or instructions; states steps to be followed in solving a problem or setting up the apparatus or carrying out an experiment or demonstration or lab exercise. Tells pupils what chemicals or equipment to use, tells pupils to look for certain structures of an organism, or to look for certain characteristics, such as shape, color, size, or to look for changes in characteristics, etc. Sometimes directions may be worded as if they were suggestions, e.g., you may try using some iodine to stain the nucleus...you may use either Benedict solution or Fehling solution. Definitions, facts, explanations, questions, etc., interspersed with directions should not be placed in category 7, but in the appropriate category.

Two sub-categories of Category 7 are as follows:

Sub-Category 7C. Teacher States Precautions or Requires Strict Adherence to certain steps in the procedure to be followed, e.g., be careful with the acid; make sure that you sterilize the inoculating needle before touching the culture.

Sub-Category 7S. Teacher Suggests or Allows Alternative or New Approaches to an Experiment, Activity or Problem. The teacher suggests an extension of the class or laboratory work. The pupil is encouraged to explore some interesting possibilities over and beyond the "required" work. Also included in this category are statements that permit or encourage pupil(s) to follow up ideas initiated by the pupil(s). The pupil is not given detailed directions to follow and the outcome of experiment or activity is not known to the pupil and possibly the teacher. The work would be voluntarily undertaken by the pupil. The suggestion may be couched in question form or stated explicitly as a choice, e.g., I wonder what would happen if...; I don't know whether it would work or not, how about trying it out...?

This category should not be used in cases where, although alternatives are given, the student has little or no choice or opportunity to exercise initiative or solve a problem, e.g., you may use either Benedict's solution or Fehling's solution.

Category 8. Teacher Asks Questions Regarding Subject Matter. This category includes questions about the subject matter only. Rhetorical questions, directives and reprimands phrased as questions, and questions about classroom routines are placed in other categories. Where applicable the following sub-categories are used: 8D, 8F, 8X, 8E, 8N, 8L, 8P. The designation 8U is used if the question (about subject matter) cannot be classified in the sub-categories.

Sub-Category 8D. Teacher Asks Pupil to Define Terms, Give Examples of the Term, Give Meaning of Words, Phrases, Sentences, Give the Name of a Process, Object, Event, Generalization. (See 6D also.) Teachers ask for definitions, etc., in many ways.

1) By asking for one or more examples of the term, e.g., give me an example of a legume; What's another one?

2) By pointing to an object, model, diagram, picture, etc., and asking the name of the referent, e.g., What is this thing or structure called?

3) By asking for synonyms, symbols, etc., e.g., What's another word for cane sugar? What is the symbol for Carbon? What does DNA stand for?

4) By giving the genus or class term and asking for the differentia; e.g., What is an artery? or by giving the differentia and asking for the genus, e.g., Blood vessels that carry blood to the heart are called what, John?

In cases where it is not clear whether the teacher is asking for a definition or for a description or fact, contextual clues and the teacher's response to the pupil's answer need to be used.

Sub-Category 8F. Teacher Asks Pupil to State Facts, Describe, Give an Account or Report of an Event. Teacher asks pupil to state facts or items of information without explanations, to give an account or report of a past or presently occurring event, situation or state of affairs. Teacher asks pupil to describe an object by stating its attributes, functions, structure, uses, etc. Teacher asks pupil to recite or recall a generalization. Teacher asks pupil to state what steps of the laboratory experiment have been taken, what data and results have been obtained, e.g., What happened when you added the solution? Did you get a 3:1 ratio? What did you add to the egg white? Contextual clues are used to decide whether the teacher is asking the pupil to state or recite or

describe what he has done or the results he has obtained or whether the teacher is asking for an explanation. (See 6F and 6X.)

Sub-Category 8X. Teacher Asks Pupil to Explain, to Make Inferences, to Compare and Contrast, to State Relationships between Objects, Events, Processes, Generalizations (See 6X also.) Teachers may ask pupils to give a full or complete explanation by asking for antecedents and consequents, e.g., explain how the rate of breathing is controlled; explain how we breathe. Teachers may "give" the antecedents, and ask the pupil to give consequents or vice-versa. Frequently, the pupil is asked to (or need only) give a word or phrase to complete the explanation; As the carbon dioxide content of the blood increases, the rate of breathing does what? Teacher asks pupil to explain why he carried out certain operations in an experiment, lab or class activity, or why he got certain results or to predict consequences, e.g., Why did you add iodine to the onion cells? Why did the cells burst? What would happen if you put the cells in distilled water? Teacher asks pupil to explain processes, to give reasons or justification for opinion or evaluation, etc.

Sub-Category 8E. Teacher Asks Pupil to Evaluate or Make Value Judgements, to Give Opinion. (See 6E also.) This category is restricted to evaluation and opinions regarding the importance, necessity, value, etc. of an object, function, process, attribute, event, etc. (not classroom behavior but rather the subject matter) e.g., What is the most important function carried out by the liver? What kind of fertilization is better, external or internal?

Sub-Category 8N. Teacher Asks Pupil to Give Information about the Nature of Science. (See 6N also.) Teacher asks pupil to give information about inter-relatedness of scientific knowledge, the processes of science, scientific attitudes, etc.

Sub-Category 8P. Teacher Asks Pupil about Problem Solving Procedures, Techniques, Steps to be taken to carry out lab activity or experiment or to solve a problem presently or in the future. Teacher asks pupil to state, describe, explain, how he would carry out an experiment or activity for which the teacher has not given directions. The experiment or activity or problem represents an extension of the class or lab work and is not required work, e.g., How would you go about finding out the effect of...? How would you set up an experiment to find out...? This category does not include questions asking a pupil to state or explain what steps of the lab directions (given by the teachers) have been carried out or how he has or will carry out the directions.

Category 9. Teacher Examines, Looks at, or Checks Pupil's Work. Teacher looks at pupil's slide under a microscope, dissection, "set up" of apparatus or other product of activity. Teacher quickly reads or checks a pupil's drawing, data, results, seat work, etc; e.g., I see the nucleus; I don't see an amoeba; I see a white blood cell on the far left; I can't find any dividing cells. The teacher may look at pupil's seat work, lab work, results, etc., either on his own initiative or in response to a question or request by a pupil.

Category 10. Teacher Asks Questions regarding Class Routines, Activities, Assignments, Procedures, Materials. In this category are included all questions related to the management of the classroom and laboratory, e.g., How many of you need more time to finish? Did you find the inoculating loop? How many people need review books? When did you have study hall? Do you understand? Is everything o.k.? How's it coming? Any questions? Did we finish the circulatory system on Friday? Did you finish already? Do you have your homework?

Category 11. Teacher Gives Routine Directives, Gives Assignments, Gives Procedural Orientation, Explicates Transition of Topics. Teacher calls class to order, excuses or dismisses the class, tells pupils to read, write, draw diagrams, to hand in work, to take out or put away books and equipment, to clean up the equipment, to put things in order. Teacher gives an assignment with or without suggestions about how to study, what to look for, etc. Announces quizzes and tests, tells what will be covered, how long test will last, how much the test will count. Teacher announces the "results" of tests, quizzes, assignments, makes comments regarding classwork, homework, tests, etc. Teacher tells pupils to be careful, neat, hurry up, to use ink. Teacher places the day's work in context, tells relationship with other topics of the courses, gives rationale, reasons for study of the specific topic or subject, explicates transitions, asks students to pay special attention to some aspect of an assignment, or chapter, or discussion, or question or statement, gives scope and limitation of a topic, assignment, provides framework or explicates frame of reference, gives cues that focus students' attention to particular aspects of the subject matter. Teacher tells pupils how teacher is going to present the material, e.g., in general terms, briefly, as an introduction to more detailed study, as details of a prior general statement, etc. Teacher tells pupils how present topic or knowledge is related to past or future subject matter. Teacher tells pupils certain topic will be covered later, etc. Teacher tells pupils that he is returning to a topic previously studied. Teacher tells pupils the reason for doing something a certain way, i.e. the rationale for class routines and procedures.

Category 12. Teacher attends to Routines and Class-Management, Takes Attendance, Distributes Materials, Prepares Materials, Performs Services. Teacher takes attendance silently or calls out pupils' names (pupils' response is not coded) distributes or collects papers, books, lab equipment and materials. Teacher prepares solutions, microscope slides, weighs material, sets up apparatus, sets up demonstration, takes care of aquaria, terraria, plants, animals, cleans up the classroom or lab. Teacher goes to shelf or stockroom or some other room to get materials. Teacher corrects papers, writes or reads at desk, looks up reference book notes, text, etc.

Category 13. Teacher Oversees Pupils at Work, Engages in Minimal Verbal Interaction. Teacher walks around the room or from one lab desk to another without stopping at any desk for longer than 4 or 5 seconds. Teacher sits or stands silently at desk or some part of the room looking at the class as a whole. He is not specifically examining any student's work at a desk but rather overseeing the work of the students. As a result of this activity he may observe one or more students doing something which may necessitate some other kind of interaction.

If the teacher stops at a desk for longer than 4 or 5 seconds and examines or looks at pupils' work use category 9. If the teacher is walking around getting or distributing materials, cleaning up or engaged in routine tasks use category 12.

Category 14. Pupil Asks for Information and Assistance. In this category are included all questions asked by pupils. Wherever applicable the following sub-categories are used, viz., 14D, 14F, 14X, 14E, 14N, 14A. The designation 14U is used if the question cannot be classified in the relevant sub-category.

Sub-category 14D. Pupil Asks for Definitions, Examples of Terms, Meaning of Words, Phrases, Sentences, Name of a Process, Object, Event.

Sub-category 14F. Pupil Asks for Facts, Description, Account or Report of Event.

Sub-category 14X. Pupil Asks for Explanation, Inference, Comparison, Relationship between Objects, Events, Processes, Generalizations.

Sub-category 14E. Pupil Asks for Evaluation or Value Judgment, Opinion about the Subject Matter.

Sub-category 14N. Pupil Asks for Information about the Nature of Science.

The criteria and examples already mentioned under category eight are applicable and need not be repeated. Note: It is often difficult to hear clearly and fully what the pupil is saying. Often the observer has to rely on fragments of a question, or repetition of the question by the teacher and sometimes infer the type of question from the response of the teacher. An important clue to remember is that the pupil is seeking substantive information of the kind mentioned under category six. Though questions are addressed most frequently to the teacher, the above sub-categories are used for questions directed to other pupils also, but only when they are asked in the course of a discussion and are permitted by the teacher. Whispered questions to pupils seated near-by are not categorized.

Sub-category 14A. Pupil Asks about Laboratory Directions, Techniques, Procedures, Materials, Classroom Routines. This category includes a major portion of questions asked in the laboratory and a relatively minor portion of questions asked in the lecture-discussion classes. Broadly speaking, questions included in this sub-category solicit assistance from the teacher in many ways. Though these questions are

not further sub-divided they will be grouped in the following examples:

1) Pupils ask for and about laboratory directions and techniques, i.e., the kind of directions included in category seven and sometimes requiring a demonstration, e.g., How much Fehling's solution do I add? How do I know when to stop heating? How does the bunsen burner work? What should I use to stain this slide? How many test tubes do I need?

2) Pupils ask for materials and services, i.e., they solicit teacher behavior included in category twelve, e.g., Where is the Fehling's solution? I need some test tubes. Where is the book?

3) Pupil asks for confirmation or verification, asks if his laboratory work or seat work is correct, right, whether it is what he is supposed to be doing, i.e., soliciting the kind of response included in categories two and three, e.g., Are those things in the center the chromosomes? Is this slide OK? Is this the color we should get? Is this blue-black?

4) Pupil asks about classroom or laboratory routines, procedures, assignments, quizzes, etc., i.e., the kind of directives included under category eleven, e.g., When is our homework due? What did I get on the test? Where is the soap? Where do I put the slides?

Category 15. Pupil Gives Information or Responds. In this category are included pupil responses to questions asked by the teacher or another pupil as well as "voluntary" information given by the pupil. Note that the response may be just a word or two or a few sentences. Wherever applicable the following sub-categories are used, viz., 15D, 15F, 15X, 15E, 15N, 15L, 15P, 15R. The designation 15U is used if the "information" cannot be classified in the relevant sub-category.

Sub-category 15D. Pupil Defines Terms, Gives Examples of Terms, Process, Object, Event, Generalization, etc.

Sub-category 15F. Pupil States Facts, Describes, Gives an Account or Report of an Event.

Sub-category 15X. Pupil Explains, Makes Inferences, Makes Comparisons, States Relationships between Objects, Events, Generalizations.

Sub-category 15E. Pupil Evaluates, Makes Value Judgment, Gives Opinion about the Subject Matter.

Sub-category 15N. Pupil Gives Information about the Nature of Science.

Sub-category 15L. Pupil Makes Statements about Lack of Information and Limitation of Knowledge.

The criteria and examples mentioned under category six are applicable and need not be repeated.

Sub-category 15P. Pupil Proposes the Procedures, Techniques or Steps to carry out lab activity or experiment or to solve a problem presently or in the future. In this category are included only those statements which are proposed by the pupil. A recitation of definitions, facts, explanations regarding teacher-given lab directions or problem-solving procedures should be coded as 15D, 15F, 15X, etc. The statements in Category 15P would be called for by the questions in sub-category 8P, e.g., in order to find out the effect of temperature on the heart beat I would...; I would set up an experiment in which...

Sub-category 15R. Pupil Gives Information regarding Routines, Classroom Procedures and Activities, Assignments, Materials. Responses in this category usually consist of a yes or no or raising of hands, phrase or a short phrase. The pupils' responses are usually solicited by questions in category ten.

Category 16. Silence. In this category are included only pauses and short periods of silence occurring after a question has been asked, a directive or a reprimand has been given, or in the middle of a sentence as teacher or pupil gropes for words or pauses to think. The silence must be at least four seconds in duration. However, in this category do not include periods of silence longer than 30 seconds encountered while pupils are reading silently or writing or carrying out laboratory activities, use the appropriate teacher behavior category, such as nine, twelve or thirteen.

Category 17. Not Categorizable in Above System. In this category are included only those statements or behaviors which cannot be classified into any of the above categories according to the criteria and definitions of this system. Wherever possible a notation should be made in the margin to indicate the behavior categorized as "17."

Ground Rules for Categorizing Teacher-Pupil Interaction

Teacher-pupil interaction is bewilderingly complex, and there is a limitless variety of nuances and gradations. A category system is after all an artificial classification scheme and the compartmentalization of the fluid, complex, process of human interaction into mutually exclusive categories is achieved by the use of more or less arbitrary "cut-off points." The aforementioned categorization and the definitions of categories should enable an observer to use the category system with a fairly high degree of reliability.

However, many problems in coding arise due to a number of factors, such as the following: inaudibility and indistinguishability of words, phrases or sentences, ambiguity, vagueness, unique stylistic devices, rapid interaction, confusion due to two or more persons talking at the same time, simultaneous occurrence of verbal and non-verbal behavior classifiable in separate categories, changes in the middle of a sentence, incomplete sentences and conflicting cues within a single sentence. It would be impractical, if not impossible, to list rules to cover every eventuality and a trained observer has to use his best judgment. However, in order to increase the objectivity of the category system, certain (arbitrary) ground rules covering the more commonly occurring problematical situations are given below:

1. Two or more persons are talking at the same time
   a) If the teacher and one or more pupils talk simultaneously, categorize the teacher's speech. (The emphasis or focus in the category system is on teacher behavior.)
   b) If two or more pupils talk simultaneously (while teacher is silent), categorize the speech of the pupil who was or is

"recognized" or "acknowledged" by the teacher.

2. Verbal and non-verbal behavior categorizable in two categories occurs at <u>exactly</u> the same time.

   a) Categorize only the verbal behavior when the non-verbal behavior is of a routine nature (category 12 and 13), for example, the teacher gives directions, gives information, asks questions, praises, reprimands, etc., while distributing materials such as laboratory supplies, papers, books, erasing the chalkboard, "setting up" a projector, etc.

   b) Categorize both verbal and non-verbal behavior when the non-verbal behavior (category 5 or 9) is in the Cognitive Dimension.

      i) Teacher gives a demonstration (category 5) and talks at exactly the same time. This situation has been observed very infrequently, usually statements or questions precede, follow, or are interspersed with various non-verbal actions constituting the "demonstration." In the rare cases of simultaneous occurrence, one pair of category numbers is written every five seconds (or sooner in case of a category shift), e.g., 5, 7, 5, 7, 5, 6X, 5, 6X, 5, 8F, 5, 8F, 5, 11, etc.

      ii) Teacher looks at a pupil's work (category 9) and talks at exactly the same time; one pair of category numbers is written every five seconds, e.g., 9, 2, 9, 3, 9, 8F, etc.

3. Observer is uncertain as to which major category to use.

   a) Categories 1 versus 2, 2 versus 3, 3 versus 4. The absence of certain cues and subtle shifts from one category to another may make coding difficult. In such cases the order of

preference is 1, 2 and 3 respectively.

b) Categories 6 versus 11, 7 versus 11, 9 versus 13. Primarily due to subtle shifts within these pairs of categories uncertainty may result as to whether a shift or change has indeed occurred. In such cases the observer should continue with the prevalent category until he is certain the shift has occurred. However, the observer must be alert to such shifts and change categories when definite shifts do occur even if the shifts occur only momentarily.

c) Categories 14 versus 15. "Pupil-Talk" is often inaudible or indistinguishable, but (fortunately) teachers often repeat a part or all of a pupil's utterance or give some other response thereby providing clues that aid in classification. If such clues are not available use category 14.

4. Observer is uncertain as to which sub-category within the major categories 6, 8, 14 and 15 should be used. Sometimes the observer is unable to decide at the end of 5, 10 or 15 seconds as to which sub-category to use. In such cases the observer writes the number of the major category alone, and then, if subsequent talk provides the necessary clues, adds the sub-category designation. If at the end of about 15 seconds the observer still cannot decide which sub-category to use, 6U, 8U, 14U or 15U is used as the case may be. The observer should attempt to minimize the frequency with which he uses the 6U, 8U, etc. (Frequent use of 6U, 8U, etc. by a "new" observer may be due to insufficient training and further training may be necessary).

5. When teacher writes on the board, categorize as if he were speaking. When teacher draws a diagram, assume that he is describing

something and categorize as 6F, but categorize the labels as 6D, explanatory comments as 6X, and evaluative comments as 6E.

6. When the teacher gives an "oral quiz" and the pupils write down the answer, categorize the teacher's talk into the appropriate sub-categories, and then, while the teacher is silent and the pupils write, assume that most of the pupils are responding appropriately to the type of question asked and use the corresponding sub-category of pupil response, e.g., teacher asks for definition--pupils write (give) definition, and hence should be coded 8D, 8D, 8D, 15D, 15D. (Note: The numbers are written every five seconds as usual.)

A Test of the Reliability of the Category System

The reliability test undertaken in this study was the determination of the degree of agreement between two observers categorizing the same classes at the same time. Scott's coefficient was calculated according to the procedure described by Amidon and Flanders (1963).

A graduate student in Science Education with no prior training in the use of category systems was trained by the writer. The training procedure is described below: (1) A general introduction to the use of category systems for the observation of classroom behavior was given. The distinction between objective description and subjective evaluation was stressed. (2) The trainee memorized the ground rules, definitions and designations of the categories. (3) The trainee practiced coding tapes of biology lectures and labs independently and under the guidance of the writer. During this phase considerable discussion took place; the more subtle distinctions and the borderline cases were discussed. The first three steps entailed a total of approximately 30 hours spread over a period of three weeks. (4) The trainee accompanied the writer to the lecture and laboratory classes of one of the teachers (teacher CD1 in Table 1) in order to practice "live" or on-the-spot coding. Following each practice session difficulties in coding and differences in interpretation of definitions of categories were discussed. The trainee practiced "live" coding during three laboratory periods and one lecture period. More practice was necessary in laboratory classes because of greater difficulty involved in coding laboratory classes. Thus a total of four practice sessions undertaken in a two-week period were necessary before the trainee was judged to have acquired a reasonably high degree of proficiency. Scott's coefficients of 0.6 or higher were reached.

Upon completion of the training period the writer and the trained observer independently coded one lecture period and one laboratory period of the above-mentioned teacher on two successive days per week for two weeks, i.e., a total of four lectures and four labs. The procedures and ground rules of the category system and definitions of categories were followed, as stated. The percentage of observations attributed by the writer (observer A) and the trained observer (observer B) to each category during four lectures and four labs are shown in Tables 2 and 3. A category by category comparison of the degree of inter-observer agreement can be made from Tables 2 and 3. The data in Tables 2 and 3 were used to calculate the Scott's coefficients of inter-observer agreement presented in Table 4. These coefficients indicate that high inter-observer agreement was achieved (0.8 to 0.9), especially during the last two visits.

Unfortunately, owing to other commitments, the trained observer was not available for more visits to the classes of teacher CD1, or for visits to the classes of other teachers. The coefficients of agreement presented in Table 4 justify confidence but cannot be considered as a conclusive demonstration of reliability of the category system. Further tests would be highly desirable.

TABLE 2 PERCENTAGE OF OBSERVATIONS ATTRIBUTED TO EACH CATEGORY BY TWO OBSERVERS DURING FOUR LECTURE PERIODS a/

Category		Lecture 1		Lecture 2		Lecture 3		Lecture 4	
		Obs A	Obs B	Obs A	Obs B	Obs A	Obs B	Obs A	Obs B
T Praises	1	1.5	2.6	0.9	2.4	3.5	4.3	1.4	2.5
T Accepts	2	7.0	8.5	8.6	9.1	6.7	7.8	5.9	7.0
T Corrects	3	1.5	1.0	1.8	1.8	1.4	1.6	1.4	1.5
T Reprimands	4	.8	1.2	.7	.3	.2	.2	.9	.8
T Demonstrates	5	0	0	0	0	0	0	0	0
T's Info Unc	6U	.4	0	0	0	.6	0	.2	0
T Defines	6D	7.9	2.4	4.1	7.2	5.8	5.7	5.9	5.1
T Gives Facts	6F	10.9	17.1	16.3	11.1	17.3	19.2	18.8	19.9
T Explains	6X	10.5	7.5	17.9	18.7	12.8	11.6	12.4	12.1
T Gives Eval	6E	1.1	2.3	1.4	2.9	3.0	3.3	.7	.9
T Nat Sci	6N	0	0	0	0	0	0	0	.8
T Lacks Info	6L	0	.9	0	0	1.9	1.2	.5	.6
Sum of 6's		30.8	30.1	39.7	39.8	41.3	41.0	38.5	39.3
T Lab Direct	7	0	0	0	0	.2	0	0	0
T Cautions	7C	0	0	0	0	0	0	0	0
T Suggests	7S	0	0	0	0	0	0	0	0
Sum of 7's		0	0	0	0	.2	0	0	0
T's Ques Unc	8U	.2	.2	0	0	0	0	.2	.2
T Asks Def	8D	6.0	2.8	5.9	2.8	3.5	3.1	4.7	4.4
T Asks Facts	8F	5.6	10.3	5.2	6.9	6.3	6.4	3.0	3.8
T Asks Expl	8X	5.3	5.9	3.1	4.1	2.1	2.8	3.8	3.4
T Asks Eval	8E	.6	2.4	0	.3	0	0	0	0
T Nat Sci	8N	0	0	0	0	0	0	0	0
T Asks Prob	8P	0	0	0	0	0	0	0	0
Sum of 8's		17.7	21.6	14.2	14.1	11.9	12.3	11.7	11.7
T Looks	9	0	0	0	0	0	0	0	0
T Asks Proc	10	3.2	3.5	.9	1.4	1.8	1.7	2.1	1.9
T Rout Dir	11	12.2	9.2	11.8	9.3	11.2	9.7	11.8	10.8
T Routines	12	3.0	2.8	5.6	5.1	4.7	4.2	5.6	4.5
T Supervises	13	0	0	0	0	.2	.3	0	0

TABLE 2 (CONTINUED)

Category		Lecture 1		Lecture 2		Lecture 3		Lecture 4	
		Obs A	Obs B	Obs A	Obs B	Obs A	Obs B	Obs A	Obs B
P's Ques Unc	14U	0.8	0	0	0	0	0	0	0
P Asks Def	14D	.6	.2	.2	0	0	0	.4	.4
P Asks Facts	14F	.2	.5	.2	.2	.2	1.0	.2	.6
P Asks Expl	14X	.8	1.4	1.3	.8	0	0	.7	1.7
P Asks Eval	14E	0	0	0	0	0	0	0	0
P Nat Sci	14N	0	0	0	0	0	0	0	0
P Seeks Asst	14A	.8	.9	.4	.6	1.1	.9	1.0	.6
Sum of 14's		3.0	3.0	2.0	1.7	1.2	1.9	2.3	3.2
P's Info Unc	15U	.9	.4	.4	0	1.4	.5	3.3	.6
P Defines	15D	3.8	1.4	3.9	2.9	3.5	2.9	4.2	3.8
P States Facts	15F	5.5	5.2	5.2	5.6	5.1	5.2	5.2	6.8
P Explains	15X	3.4	3.0	2.5	3.5	1.9	2.4	2.8	2.7
P Gives Eval	15E	.4	.7	0	.5	0	.2	0	0
P Nat Sci	15N	0	0	0	0	0	0	0	0
P Lacks Info	15L	.6	.7	0	0	.4	.2	.5	.4
P Gi Prob Solv	15P	0	0	0	0	0	0	0	0
P Gi Rt Info	15R	3.8	4.0	.7	1.4	2.6	2.8	1.4	2.5
Sum of 15's		18.2	15.3	12.7	13.9	14.9	14.2	17.4	16.6
Silence	16	.9	.7	.9	.8	.7	.4	.7	.6
Unclassifiable	17	0	0	0	0	0	0	0	0
N		531	573	557	623	570	575	572	529

a/ Figures = % of total observations in each lecture class.

TABLE 3 PERCENTAGE OF OBSERVATIONS ATTRIBUTED TO EACH CATEGORY BY TWO OBSERVERS DURING FOUR LABORATORY PERIODS a/

Category		Laboratory 1		Laboratory 2		Laboratory 3		Laboratory 4	
		Obs A	Obs B	Obs A	Obs B	Obs A	Obs B	Obs A	Obs B
T Praises	1	1.0	1.3	0.3	0.6	0.8	1.2	0.2	0.2
T Accepts	2	2.5	.6	.3	.6	2.8	2.0	1.8	2.6
T Corrects	3	.4	.2	0	0	1.0	.8	.6	.9
T Reprimands	4	.2	.2	0	0	0	0	.7	.5
T Demonstrates	5	.8	1.3	0	0	.6	.8	2.6	1.2
T's Info Unc	6U	.2	.4	0	0	0	0	0	0
T Defines	6D	0	.2	0	0	3.0	2.2	1.8	1.1
T Gives Facts	6F	9.2	11.9	8.5	6.9	6.6	5.3	7.1	8.2
T Explains	6X	8.4	5.4	3.8	4.3	1.0	3.0	0	.5
T Gives Eval	6E	2.3	2.9	1.2	.9	1.0	1.0	.9	.2
T Nat Sci	6N	.2	0	0	0	0	0	0	0
T Lacks Info	6L	.5	1.6	.9	1.1	0	0	0	.2
Sum of 6's		20.9	22.6	14.3	13.2	11.6	11.5	9.8	10.2
T Lab Direct	7	7.8	7.9	6.4	8.3	12.0	11.5	8.4	8.9
T Cautions	7C	.6	.4	.9	0	.2	.2	.4	.2
T Suggests	7S	.2	.2	.9	0	0	0	0	0
Sum of 7's		8.6	8.6	8.8	8.3	12.2	11.7	8.7	9.1
T's Ques Unc	8U	.2	0	0	0	0	0	0	0
T Asks Def	8D	0	0	0	0	.4	.8	3.1	2.3
T Asks Facts	8F	1.6	1.7	2.3	.6	2.0	1.2	2.9	3.7
T Asks Expl	8X	4.3	3.6	.9	2.6	.2	.8	0	.2
T Asks Eval	8E	0	.4	0	0	0	0	0	0
T Nat Sci	8N	0	0	0	.3	0	0	0	0
T Asks Prob	8P	0	0	0	0	0	0	0	0
Sum of 8's		6.2	5.6	3.2	3.4	2.6	2.8	6.0	6.1
T Looks	9	6.4	8.0	6.7	9.2	7.4	7.7	5.1	3.2
T Asks Proc	10	2.9	4.2	1.8	1.7	3.0	3.0	1.1	1.4
T Rout Dir	11	15.0	14.4	9.6	6.9	6.6	6.7	9.1	8.8
T Routines	12	9.6	7.7	39.4	44.0	20.6	21.4	36.4	37.3
T Supervises	13	9.0	9.4	6.1	2.0	17.0	14.3	5.8	6.3

TABLE 3 (CONTINUED)

Category		Laboratory 1		Laboratory 2		Laboratory 3		Laboratory 4	
		Obs A	Obs B	Obs A	Obs B	Obs A	Obs B	Obs A	Obs B
P's Ques Unc	14U	0	0.2	0	0	0	0.2	0	0.4
P Asks Def	14D	0	0	0	0	.2	.4	0	0
P Asks Facts	14F	.8	1.9	.3	.6	1.8	1.0	1.3	2.1
P Asks Expl	14X	1.0	1.1	0	0	.2	0	0	0
P Asks Eval	14E	0	0	0	0	0	0	0	0
P Nat Sci	14N	0	0	0	0	0	0	0	0
P Seeks Asst	14A	3.9	3.1	3.8	3.4	3.0	5.0	3.8	3.3
Sum of 14's		5.7	6.3	4.1	4.0	5.2	6.7	5.1	5.8
P's Info Unc	15U	.6	0	0	.3	4.0	3.7	.4	.7
P Defines	15D	0	0	0	0	.6	.8	2.2	1.6
P States Facts	15F	3.3	2.5	3.8	.9	3.6	1.4	2.6	2.6
P Explains	15X	2.9	2.5	.3	.3	.2	.4	0	0
P Gives Eval	15E	0	0	0	0	0	.2	0	0
P Nat Sci	15N	0	0	0	0	0	0	0	0
P Lacks Info	15L	.2	0	0	.3	.4	0	.6	0
P Gi Prob Solv	15P	0	0	0	0	0	.2	0	0
P Gi Rt Info	15R	3.1	3.8	1.2	2.9	1.7	2.1	.4	1.6
Sum of 15's		10.1	8.8	5.3	4.6	8.4	8.7	6.0	6.5
Silence	16	.6	1.1	.6	1.7	.4	.4	1.1	.4
Unclassifiable	17	0	0	0	0	0	0	0	0
N		487	479	342	350	501	494	550	573

a/ Figures = % of total observations in each laboratory class.

TABLE 4 COEFFICIENTS OF AGREEMENT OF TWO OBSERVERS IN FOUR LECTURE AND LABORATORY CLASSES a/

	Lecture Number				Laboratory Number			
	1	2	3	4	1	2	3	4
Coefficient of agreement based on major categories	.82	.81	.90	.91	.86	.76	.91	.89
Coefficient of agreement based on all categories	.54	.61	.85	.80	.74	.60	.78	.79

a/ Data used in calculation of Scott's coefficients are presented in Tables 2 and 3.

Scott's coefficient of agreement $\pi = \frac{P_o - P_e}{1 - P_e}$

P_o = Proportion of agreement 100 - total % disagreement

P_e = Proportion of agreement by chance $= \sum_{i=1}^{k} p_i^2$

k = number of categories

p_i = % in each category

CHAPTER IV

TEACHER-PUPIL INTERACTION IN BIOLOGY CLASSES

Procedure

The category system developed in this study was used during the Spring of 1965 for the observation of teacher-pupil interaction in high school biology lecture-discussion-recitation classes and laboratory classes. The major purposes of this second phase of the study were to test and demonstrate the useability of the category system and to obtain data that would permit an objective quantitative description of biology teaching (within limits of the sample size).

In addition to the eight teachers who participated in the category development phase of this study, six other teachers were selected according to the same criteria listed earlier. However, due to unexpected and unforseen circumstances, such as changes in scheduling of laboratory periods, four out of the eight teachers who had participated in the category development phase could not be observed as planned. In short, the data reported in the ensuing sections are based on observations of a "sample" of ten high school biology teachers. Pertinent information about selected characteristics of these ten teachers and the co-operating schools is presented in Table 5. The teachers are referred to by numbers one to ten instead of by name to preserve their anonymity

As shown in Table 5, the teachers' ages ranged from 25 to 40 years, the maximum teaching experience was about 10 years. Four teachers had Master's degrees and six had Baccalaureate degrees; most of the teachers had taken additional course work beyond their degrees. Seven teachers taught the New York State Regents Course, two teachers taught the BSCS

TABLE 5 SELECTED CHARACTERISTICS OF TEACHERS AND SCHOOLS CO-OPERATING IN PHASE 2

Characteristics	Teacher Number 1	2	3	4	5	6	7	8	9	10
Age as of 9/64	40	30	30	29	32	35	40	24	33	35
Sex	M	M	M	F	M	M	M	M	M	M
Total years teaching - 9/64	8	3	6	8	7	6	9	2	5½	5
Years teaching other Sci. - 9/64	6	3	6	8	7	-	9	-	-	5
Years teaching Biol. - 9/64	2	2	2	½	5	6	4	2	5½	4
Highest degree held	BS	BA	M.Ed.	BS	BS	MS	MS	BS	MS	BA
Additional credit hours	48	29	33	30	45	-	-	14	12	60
Undergraduate Major	Agri.	Econ.	G.Sci.	Sci.	Bio.	Forest.	Bio.	Bio.	Bio.	Agri.
Graduate Major	Agri.	Bio.	G.Sci.	-	Ed.	Zool.	Bio.	Bio.	G. Sci.	Sci.Ed.
Graduate Minor	Ed.	Ed.	Ed.	-	Bio.	Ed.	Ed.	-	-	Bio.
Credit hours in Biology	45	28	32	19	90	97	50	40	51	60
Credit hours in other sciences	25	10	55	37	16	18	24	6	38	38
Credit hours in math	0	3	24	9	0	6	12	3	12	0
Credit hours in Education	23	12	30	30	40	24	30	24	21	30
No. of In-Service Institutes	1	0	3	3	2	1	0	0	1	2

TABLE 5 (CONTINUED)

Characteristics	Teacher Number 1	2	3	4	5	6	7	8	9	10
No. of classes taught/day	4	5	5	5	4	4	4	5	6	4
Average class size	21	26	26	22	35	24	24	25	27	22
Length of class periods (Min.)	46	40	40	40	43	41	41	43	42	50
Type of class observed (Regents, BSCS, N.Y. Expt'l)	R	R	R	R	R	BSCS	BSCS	R	R	NY Ex.
No. of pupils in lect. observed	28	26	27	22	33	23	18	26	25	23
T's estimate of P's ability	Above Ave	Below Ave	Above Ave	Ave	Above Ave	Ave	Ave	Ave	Ave	Ave
No. of pupils in lab observed	12	14	8	10	9	24	19	23	16	23
T's estimate of P's ability	Above Ave	Ave	Ave	Ave	Ave	Below Ave	Ave	Ave	Ave	Ave
Size of School District	1600	6200	6200	6200	1850	14,000	14,000	2575	3200	8200
Pupils in grades 9-12	425	1500	1500	1500	450	2950	2950	675	1100	2000
Pupils in Sci. grades 9-12	275	875	875	875	325	2075	2075	375	550	1200
Sci. Teachers grades 9-12	3	9	9	9	6	18	18	4	4	11
Annual per pupil expenditure	575	525	525	525	500	600	600	550	650	1000

(Green Version) course and one teacher taught the New York State Experimental Course but used the BSCS Green Version text and laboratory manual. The number of pupils in the lecture classes was usually about 25 while the number of pupils in laboratory classes varied from 8 to 24. In a number of schools the smaller number of pupils in laboratory classes was due to the size of the laboratory or due to staggered scheduling. In general, ability levels of the pupils in the lecture classes observed by the writer were comparable to the ability levels of pupils in the laboratory classes observed. The teachers estimated the pupils' level of ability as "average" in most cases. The size of the school districts ranged from about 1600 to 14,000. It should also be noted in Table 5 that the teachers numbered two, three, and four taught in one school and the teachers numbered six and seven taught in one school. This brief description of the "sample" emphasizes only a few of the many factors or variables that may be reasonably assumed to affect classroom interaction. The reader is reminded that the purpose of the second phase of this study is to describe teacher-pupil interaction and not to calculate statistical correlations.

Each of the above-mentioned ten teachers was visited once each week for four or five successive weeks in order to record and categorize four lecture classes and four laboratory classes per teacher. During each visit the classroom discourse for the entire duration of one lecture and one laboratory class was recorded on magnetic tape. The teacher-pupil interaction was coded on-the-spot, using the category system developed in the first phase of this study.

At the end of each class period, the observer's record consisted of approximately 500 observations or numbe Each number, representing one of the forty-five categories, was us d to classify a segment of

behavior every five seconds (or less) as described earlier. The average duration of each lecture or laboratory class period was about 43 minutes with two exceptions. Teacher number six and teacher number seven had "double-period labs" lasting about 80 minutes. Thus the raw data for the 40 lecture classes (4 lectures for each of 10 teachers) consisted of 20,122 individual numbers or observations. The raw data for the 40 laboratory classes (4 labs for each of 10 teachers) consisted of 24,046 observations. The larger number of observations in laboratory classes was primarily due to teachers six and seven having "double-lab periods." It would be more accurate to say that 48 laboratory periods were observed. To simplify the reporting and discussion the writer will not continuously distinguish between single and double laboratory periods. The double laboratory period may be conveniently regarded as a laboratory <u>class</u> of longer duration.

The observations or category numbers were written sequentially in horizontal rows on ruled sheets of paper. For instance, the record for one minute of teacher-pupil interaction would be written as follows: 11, 11, 11, 11, 11, 6F, 6F, 6F, 8F, 3F, 15F, 2. These "numbers" indicate the original sequence of behavior as well as the duration of each category of behavior since each number is written at approximately five-second intervals. The above line can be decoded as follows: The teacher gives routine directions, assignments, etc., for 25 seconds, gives substantive facts for 15 seconds, and then asks pupil for factual information for the next 10 seconds. The pupil replies for about 5 seconds, and the teacher accepts the answer as being correct.

The data were punched on IBM data cards in such a manner as to preserve the same sequence of category numbers as recorded in the classes. The data were processed via a Control Data Corporation 1604 computer at

the Cornell Computing Center. Two programs were written and used. Since there were virtually no entries in category seventeen, i.e., "interaction not categorizable in system," the programs were written to plot the data into 16x16 matrices and 44x44 matrices corresponding to the 16 major categories and the 44 categories (16 major categories plus 28 sub-categories). In order to plot 16x16 matrices, all sub-categories of a particular major category were pooled or combined; for instance, 6U, 6D, 6F, 6X, 6E, 6N, 6L were entered or tallied as "6", and 7, 7C, 7S were tabulated as "7" and so on for the sub-categories of 8, 14, and 15. By tabulating or plotting the data into matrices of different sizes, the data can be analyzed at different levels of detail. Since the technique of plotting interaction matrices is fairly new, and has not been described widely in the literature, the writer will summarize the method for plotting a matrix. For more extensive information the reader may refer to Amidon and Flanders (1963), Flanders (1962) or Flanders (1964 b.)

The method of plotting an interaction matrix is illustrated below with a sequence of category numbers representing the first two minutes of an observational record: 16, 11, 11, 10, 15, 8, 8, 15, 2, 8, 15, 2, 11, 11, 11, 6, 6, 6, 6, 6, 8, 15, 3, 8, 15, 2, 16 (for purposes of illustration the sub-category designations are omitted). The first step in tabulating the matrix is to ensure that the entire series begins and ends with the same number so that the total number of entries in any row will be equal to the total number of entries in the corresponding column. Thus, as can be seen in Figure 1, the total number of tallies in row 1 and column 1 are the same. Similarly, the totals in row 2 and column 2 are the same, and so on. This is accomplished by placing a "16" at the beginning and end of the series. Sixteen is selected because the interpretation of the matrix is least affected by category sixteen (Silence).

The second step involves marking off the numbers in overlapping pairs as shown: 16 11 11 10 15, etc. The first pair is 16-11, the second pair is 11-11, the third pair is 11-10, and so on. Then each pair is entered into the matrix one at a time so that the first number of each pair is placed in the appropriate horizontal row and the second number of that pair is placed in the appropriate vertical column. Thus the first pair: 16-11, is entered in row 16 and column 11 as one entry or tally. The tallies are shown by slanted lines in Figure 1. The second pair, 11-11, is entered in row 11 and column 11. The third pair, 11-10, is entered in row 11 and column 10 and so on.

The entries or tallies in each cell can be readily converted to percentages of total entries in the matrix. Thus in the illustration, the total number of entries is 25, and hence the 4 entries in the 6-6 cell constitute 16 percent, the 3 entries in the 8-15 cell constitute 9 percent, the total of 5 entries in row 6 or column 6 constitute 20 percent, and so on. By expressing the entries in each cell as a percentage of total entries in a matrix, comparison of entries in two or more cells is greatly facilitated, especially when cell or row totals of two or more matrices are compared.

Each row or column total in a matrix represents the frequency of occurrence of a particular category of behavior. For instance, in Figure 1 there are no entries in row 1 (or in column 1) since there were no instances of the category one, Teacher Praises, in the two minute observational record from which Figure 1 was plotted. On the other hand, there are 4 entries in row 8 or column 8, thus the frequency of occurrence of category eight is 4 out of 25 or 16 percent of total entries in the matrix.

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1																	0
T. Accepts P's Response	2								/			/					/	3
T. Corrects P's Response	3															/		1
T. Reprimands Pupil(s)	4																	0
T. Demonstrates	5																	0
T. Gives Substantive Info.	6						////		/									5
T. Gives Lab. Directions	7																	0
T. Seeks Substantive Info.	8								/							///		4
T. Looks at P's Work	9																	0
T. Asks Procedural Ques.	10															/		1
T. Gives Procedural Direc.	11						/				/	///						5
T. Attends to Routines	12																	0
T. Supervises	13																	0
P. Seeks Information	14																	0
P. Gives Information	15		///	/					/									5
Silence	16											/						1
Total in Each Category		0	3	1	0	0	5	0	4	0	1	5	0	0	0	5	1	25

FIGURE 1 AN ILLUSTRATION OF THE TABULATION OF AN INTERACTION MATRIX. The slanted lines are tallies or entries representing a two-minute sample of classroom interaction--see text for explanations.

In the foregoing pages, the technique of plotting an interaction matrix and calculating various cell, row and column frequencies has been described. This task is extremely time consuming and laborious and computer facilities are essential. The data obtained in this study were processed via a 1604 computer to yield various matrices as follows.

1. Ten 16x16 and ten 44x44 "lecture matrices" -- one matrix (of each size) per teacher plotted from the data of four lecture classes.
2. Ten 16x16 and ten 44x44 "laboratory matrices" -- one matrix (of each size) per teacher plotted from the data of four laboratory classes.
3. One 16x16 and one 44x44 "grand matrix" for all 40 lecture classes of 10 teachers.
4. One 16x16 and one 44x44 "grand matrix" for all 40 laboratory classes of 10 teachers.

In addition to the above matrices, various other scores were also obtained. For instance, in addition to the frequency of occurrence of each category expressed as percentage scores, the computer was programmed to sum the frequencies in the various categories constituting each of the dimensions and sub-dimensions of the category system. The data are discussed in the next section.

Results and Discussion

The overwhelming wealth and detail of data obtained from interaction analysis can be organized and presented in many ways. The data are usually presented as frequencies or percentage scores in tabular and graphic form. In the ensuing sections the data from four lecture classes of each of the ten biology teachers will be pooled. The number of observations recorded in each of the major categories and sub-categories will be expressed as a percentage of the tot. observations, approximately 2000, recorded in four lecture classes for each teacher. The data from the four laboratory classesof each teacher will be presented in the same manner. This procedure reduces the raw data of over 44,000 observations or numbers (20,122 in 40 lectures and 24,046 in 48 lab. periods) to about 500 percentage scores as presented in Tables 6 and 7.

In the interest of comprehensibility and clarity of discussion, various portions of the data in Tables 6 and 7 will be presented in a number of separate tables. Each table will highlight certain aspects and dimensions of classroom behavior.

The writer views Tables 6 and 7 as "Master Tables" in which virtually all the quantitative information has been summarized. These tables give the distribution of categories in lectures and labs by teacher. For example, from Table 6, it can be seen that 2.2 percent of all observations recorded in the four lecture classes of teacher number one, were attributed to category one, teacher praises pupils. Whereas, for teacher number two only 0.2 percent of all observations were attributed to category one. Since each observation or entry represents about five seconds of time, for purposes of discussion,

TABLE 6 RELATIVE FREQUENCIES OF INTERACTION-CATEGORIES IN LECTURE CLASSES OF 10 BIOLOGY TEACHERS a/

Category		Teacher Number 1	2	3	4	5	6	7	8	9	10	Avc.
T Praises	1	2.2	0.2	2.1	1.9	3.3	1.0	0.3	1.7	0.4	0.9	1.4
T Accepts	2	7.8	6.7	8.8	8.3	4.3	1.5	5.6	4.5	4.5	3.5	5.5
T Corrects	3	1	1.3	1.8	.9	.8	1	1.1	1.9	1.5	.5	1.2
T Reprimands	4	.4	.1	1.2	1.5	.7	3.1	1.8	3.9	.1	.4	1.3
T Demonstrates	5	0	0	0	0	.4	.1	.1	0	.9	0	.1
T's Info Unc	6U	0	0	0	0	0	0	0	0	0	0	0
T Defines	6D	4.2	5.7	3.6	7.3	7.1	2.1	10.3	8.7	4.6	4.4	5.7
T Gives Facts	6F	20.1	24.7	13	17.7	26.5	14.9	20.4	13.6	18.7	16.5	18.7
T Explains	6X	15.9	20	11.2	4.7	18.8	14.4	8.2	11.8	21.7	27.8	15.8
T Gives Eval	6E	3.1	1.3	1.2	1.8	3.1	1.4	.8	3.1	2.5	1.3	2
T Nat Sci	6N	0	0	0	0	0	0	0	0	.1	0	0
T Lacks Info	6L	.2	.3	.1	1	0	.9	0	.1	.4	.3	.3
Sum of 6's		43.5	52	29.1	32.5	55.5	33.7	39.7	37.3	48	50.3	42.5
T Lab Direct	7	.1	0	0	0	.2	.2	1.4	.1	.1	.7	.3
T Cautions	7C	0	0	0	0	0	0	.5	0	0	0	.1
T Suggests		0	0	0	0	0	0	0	0	0	0	0
Sum of 7's		.1	0	0	0	.2	.2	1.9	.1	.1	.7	.3
T's Ques Unc	8U	0	.3	0	0	0	0	0	0	0	0	0
T Asks Def	8D	4.5	2.6	4.4	5.8	2.7	1	3.7	4.2	3.5	1.5	3.4
T Asks Facts	8F	5.3	5.9	7.5	7.6	3.2	5.1	3.7	4	1.6	1.3	4.4
T Asks Expl	8X	7	2.9	4.6	1.4	1.6	.9	3.3	3.7	4.4	3.2	3.3
T Asks Eval	8E	.2	.1	.2	.2	.1	0	0	.4	.1	.1	.1
T Nat Sci	8N	0	0	0	0	0	0	0	0	0	0	0
T Asks Prob	8P	0	0	0	0	0	0	0	0	0	0	0
Sum of 8's		17	11.9	16.7	15	7.6	7	10.7	12.3	9.4	6.1	11.3
T Looks	9	0	0	.2	.2	0	0	.2	1.8	.1	.5	.3
T Asks Proc	10	1.2	.2	.9	3	1.4	2	1.1	2.3	1.6	1.3	1.5
T Rout Dir	11	10.5	9.7	5.9	12.7	11.9	14.4	10.5	11.2	12	16.4	11.7
T Routines	12	1.2	2	1.6	1.9	3.4	12	6.6	2.9	2.5	6.1	4
T Supervises	13	.8	0	4.3	0	.1	0	0	.6	.7	.4	.7

TABLE 6 (CONTINUED)

Category		Teacher Number 1	2	3	4	5	6	7	8	9	10	Ave.
P's Ques Unc	14U	0.3	0.2	0	0.1	0	0.2	0	0.1	0.1	0	0.1
P Asks Def	14D	.1	.4	0	.2	.1	.2	.3	.1	.3	.3	.2
P Asks Facts	14F	.4	.4	.5	.9	.1	.9	1.6	.1	1.2	.4	.6
P Asks Expl	14X	.4	1.1	1.2	.3	.3	2.9	.4	0	3.3	1.3	1.2
P Asks Eval	14E	0	.1	0	0	0	0	0	0	.3	0	0
P Nat Sci	14N	0	0	.1	0	0	0	0	0	0	0	0
P Seeks Asst	14A	.2	.4	.2	.2	.5	.8	1.1	.1	1.2	.8	.6
Sum of 14's		1.4	2.6	2	1.7	1	5	3.4	.4	6.4	2.8	2.7
P's Info Unc	15U	.2	.2	.4	.2	.1	1	0	.8	.1	.7	.4
P Defines	15D	2.9	1.6	4.5	6	2.9	2.4	2.7	4.9	1.9	1.4	3.1
P States Facts	15F	3.6	5.4	6.5	10	3.2	9.3	5.7	4	1.7	2.8	5.1
P Explains	15X	3.5	2.5	5.3	1.5	1.3	1.5	2.4	2	5.2	3.6	2.9
P Gives Eval	15E	.1	.3	.2	.2	.1	.1	0	.2	.2	.1	.1
P Nat Sci	15N	0	0	.1	0	0	0	0	0	0	.2	0
P Lacks Info	15L	.1	.4	1	.5	.1	.3	.6	.4	0	.1	.3
P Gi Prob Solv	15P	.5	0	0	0	0	0	0	0	0	0	0
P Gi Rt Info	15R	.2	.1	.3	.9	.7	1.2	.2	.4	.8	.4	.5
Sum of 15's		10.7	10.4	18.3	19.3	8.4	15.8	11.6	12.7	9.9	9.3	12.4
Silence	16	2.1	3.2	7.1	1.1	1.4	3.2	5.4	6.6	1.7	1	3.2
Unclassifiable	17	0	0	0	0	0	0	0	0	0	0	0
N		2245	1971	1712	2014	1988	2048	1837	1862	2233	2213	2012

a/ Figures = % of total observations in 4 lecture classes per teacher.

TABLE 7 RELATIVE FREQUENCIES OF INTERACTION-CATEGORIES IN LABORATORY CLASSES OF 10 BIOLOGY TEACHERS a/

Category		Teacher Number 1	2	3	4	5	6	7	8	9	10	Ave.
T Praises	1	0.3	0.2	0.4	2.8	2.0	0.3	0.3	2.1	1.0	0.7	0.9
T Accepts	2	1.7	4.2	1	2.5	1.4	1.8	1.5	.7	1	1.7	1.7
T Corrects	3	.2	1.2	.7	.7	.4	.6	.3	.4	.2	.7	.5
T Reprimands	4	.4	.7	.7	.7	.2	2	1.3	2.3	.4	.2	1
T Demonstrates	5	4.7	8.8	1.8	2.7	4.5	5	2.7	3.2	.3	1.1	3.4
T's Info Unc	6U	.2	0	0	.1	0	0	0	0	0	0	0
T Defines	6D	.4	4.3	0	1.8	1.7	1.3	1.2	.3	2.1	2.9	1.6
T Gives Facts	6F	6	15.1	1.6	6.4	11.5	4.1	3.8	1.9	3.6	6.7	5.6
T Explains	6X	8.4	10.1	3.4	4.3	6	3.6	2.2	1.6	13.4	10.4	5.9
T Gives Eval	6E	1	.7	.1	.5	.7	.2	0	.6	.2	.3	.4
T Nat Sci	6N	0	0	0	0	.2	.1	0	0	0	0	0
T Lacks Info	6L	.2	.1	0	.4	.3	.2	0	0	0	.2	.1
Sum of 6's		16.2	.3	5.1	13.5	20.4	9.5	7.2	4.4	19.3	20.5	13.6
T Lab Direct	7	16.5	3.1	14.2	11.8	14	10.7	10.9	6.7	10.7	15	11.3
T Cautions	7C	.8	.1	.1	.2	.2	.5	.6	.3	.3	.2	.4
T Suggests	7S	.3	0	.2	.1	.6	.2	.1	.2	0	0	.2
Sum of 7's		17.6	3.2	14.5	12.1	14.8	11.4	11.6	7.2	11	15.2	11.9
T's Ques: Unc	8U	0	0	.2	.1	0	0	0	0	0	0	0
T Asks Def	8D	.2	1.2	0	1.2	.4	.7	.9	.1	.3	1.5	.7
T Asks Facts	8F	2.9	4.9	1.3	6.2	1.9	2.2	1.8	2	1.7	1.1	2.4
T Asks Expl	8X	1.3	2.1	.4	1.3	.9	1.2	.7	.2	1.1	1.1	1
T Asks Eval	8E	.1	.2	0	.1	.1	0	0	.1	0	0	0
T Nat Sci	8N	0	0	0	0	0	0	0	0	0	0	0
T Asks Prob	8P	.4	0	.7	.1	.3	.2	.5	.1	.6	0	.3
Sum of 8's		4.9	8.4	2.6	9	3.6	4.3	3.9	2.5	3.7	3.7	4.4
T Looks	9	10.7	1.9	14.8	4.6	7.2	4.2	5.3	23	20	2.7	8.7
T Asks Proc	10	3.7	2.2	1.8	3.5	1.9	2.2	.9	3.2	2.5	1.7	2.2
T Rout Dir	11	7.5	10.7	3.2	11.8	14.3	14.5	14	8.5	5.7	21	12.2
T Routines	12	10.9	8.2	25.7	10.5	16.3	20.5	18.8	12.9	10.2	13.3	15.5
T Supervises	13	8.9	4.3	10	4.6	.3	8	16.5	16.2	15.2	3.8	9.6

TABLE 7 (CONTINUED)

Category		Teacher Number 1	2	3	4	5	6	7	8	9	10	Ave.
P's Ques Unc	14U	0.3	0.2	0.2	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.1
P Asks Def	14D	.1	.8	0	.1	.2	.4	.2	.2	.2	.3	.3
P Asks Facts	14F	.2	1.1	.2	.4	.5	1.8	1.3	.2	.1	1.2	.8
P Asks Expl	14X	.5	.5	.2	.4	.5	1.2	.3	.1	.7	1.3	.6
P Asks Eval	14E	.1	0	0	0	0	0	.2	0	0	0	0
P Nat Sci	14N	0	0	0	0	.1	0	0	0	0	0	0
P Seeks Asst	14A	3.8	.8	6.7	1.9	4.6	5.6	7.6	3.3	1.8	5.4	4.6
Sum of 14's		5	3.4	7.3	2.8	5.9	9	9.6	3.9	3	8.2	6.4
P's Info Unc	15U	.3	.1	.3	.8	.2	.1	.1	1	.2	.7	.3
P Defines	15D	.1	1.1	0	1.4	.4	.7	.6	.2	.2	1.1	.6
P States Facts	15F	3.9	5	2.3	10.7	3	3	2.4	2.3	2.1	1.2	3.3
P Explains	15X	.8	2	.7	1.4	.8	1.2	.6	.4	.7	.9	.9
P Gives Eval	15E	.1	.1	.1	.2	.1	0	0	.1	0	0	0
P Nat Sci	15N	0	0	0	0	0	0	0	0	0	0	0
P Lacks Info	15L	0	.6	0	.4	.1	.2	.3	.2	.5	0	.2
P Gi Prob Solv	15P	.2	0	.3	0	.3	0	0	0	0	0	.1
P Gi Rt Info	15R	1.5	1.4	1	2.4	1.6	.7	.5	2.7	1.5	.8	1.3
Sum of 15's		6.9	10.3	4.7	17.3	6.5	5.9	4.4	6.9	5.2	4.7	6.7
Silence	16	.6	2.1	.8	.6	.6	.8	1.5	1.2	1	.6	1
Unclassifiable	17	0	0	0	0	0	0	0	0	0	0	0
N		1836	1798	1833	1874	1855	3824	4374	2001	2284	2367	2404

a/ Figures = % of total observations in 4 laboratory classes per teacher; teachers 6 & 7 had "double-period" labs.

the classroom behavior can be more conveniently referred to in terms of the amount of time spent in a given behavior. Hence, to rephrase the above example, teacher number one praised pupil 2.2 percent of the time, but teacher number two praised pupils only 0.2 percent of the time. By reading across a given row in Tables 6 and 7, the percentage of time "devoted" to any given category by the various teachers can be compared. By reading down each column of figures the percentage of time "devoted" by a particular teacher to the various categories can be compared.

The reader's attention is drawn to the extremely low percentage scores (zero percent in many cases) in the rows designated as 6U, 8U, 14U, and 15U in Tables 6 and 7. The reader may recall that according to the Ground Rules and Definitions of the Category System, category numbers 6U, 8U, 14U, and 15U are to be used only if the observer cannot classify the behavior in the appropriate sub-category. Hence, low scores in the above-mentioned rows constitutes evidence that the sub-categories were rigorously and clearly defined so that all or most of the behavior in the substantive information giving and seeking sub-dimensions was classified in the appropriate sub-categories, especially when the teacher spoke. The percentage scores in 14U and 15U were slightly higher than those in 6U and 8U primarily due to inaudibility and mumbling by the students. In the review of literature, it was pointed out that Smith et. al. (1962 b.) and Bellack and Davitz (1963) had used tapescripts to code the logical operations of teaching. The writer's attempt at simplification of Smith's and Bellack's definitions of the logical operations has apparently been successful as "evidenced" by the low percentage scores in 6U, 8U, 14U, and 15U.

In order to simplify the discussion of various tables and matrices, the writer will most frequently refer to the "average" teacher or "average" pupil rather than individual teachers or pupils. The percentage scores attributed to the so called "average" teacher, or "average" pupil in various tables were obtained from the row or column totals of the "grand matrices" based on all 40 lecture periods or all 48 laboratory periods respectively. More accurately, the so called "average" teacher (or "average" pupil) is a composite or blend of all the teachers (or pupils) observed in the second phase of this study. The percentage figures or "scores" of this composite or "average" teacher and the "average" pupil will be used to provide a descriptive model or "picture" of teacher-pupil interaction in the biology lecture and laboratory classes observed in <u>this</u> study, and <u>not</u> a prescriptive or ideal model. The writer does not claim that this model is representative of all or even a majority of high school biology classes.

In view of the exploratory nature of this study one of the major objectives is to raise questions from a consideration of the data. At times the discussion will even be deliberately speculative and certain generalizations will be made with full awareness of the limitations of available data. It is hoped that at least a few of these questions and speculations will have germinal and heuristic value for further research.

General Features of Teacher-Pupil Interaction in Lectures and Laboratories

1. Teacher Talk

The predominant feature of biology classroom life was that the teacher talked most of the time. As shown in Table 8, the average teacher talked about 75 percent of the total time in lecture-classes and about 50 percent of the total time in laboratory classes.

2. Pupil Talk

In marked contrast to the amount of teacher talk, only about 15 percent of the time was used in pupil talk and, moreover, the amount of pupil-talk was essentially the same in lectures and labs. It should be recalled that informal pupil-pupil whispering, socializing and talking was not included under pupil talk. The observer's subjective impression was that a considerable amount of such activity was prevalent in the laboratory classes and would constitute a challenging area for research.

3. Teacher's Non-Verbal Behavior

The average teacher's non-verbal behavior accounted for nearly 40 percent of the time in the labs, almost five times as much as in lectures. These figures clearly support the writer's earlier statements that a category system was needed to categorize pedagogically relevant non-verbal behavior, especially in laboratory classes and to a lesser extent in lecture classes.

4. Silent Pauses

Silent pauses in the classroom communication process, essentially between questions and answers, accounted for three percent and one percent of the time in lectures and labs respectively. Possibly this difference was due to the greater amount of time devoted by teachers to questioning and recitation in lectures than in labs. The range of

TABLE 8 GENERAL FEATURES OF TEACHER-PUPIL INTERACTION IN LECTURE AND LABORATORY CLASSES OF 10 BIOLOGY TEACHERS a/

T. No.	Teacher Talk b/		Teacher's Non-Verbal Behavior		Pupil Talk		Silence	
	Lects.	Labs	Lects.	Labs	Lects.	Labs	Lects.	Labs
1	83.7	52.4	4.1	35.6	12.1	11.8	2.1	0.6
2	81.6	61	5.3	25.1	12.9	13.7	3.2	2.1
3	66.6	35	13.1	52.9	20.1	11.9	7.1	0.8
4	75.9	56.6	3	22.9	20.9	20.3	1.1	0.6
5	85.8	59	5	28.3	9.3	12.4	1.4	0.6
6	64	46.6	15	38.4	20.7	14.8	3.2	0.8
7	72.3	41.1	12.1	44.7	14.8	14.1	5.4	1.5
8	75.2	31.7	11.7	56.4	12.9	10.9	6.6	1.2
9	77.8	44.9	5.7	46.7	16.4	8.2	1.7	1.0
10	80.1	65.7	7.8	21.3	11.8	12.8	1.0	0.6
Ave.	76.3	49.4	8.3	37.2	15.1	13.1	3.2	1.0
Range	64-86	32-66	3-13	21-56	12-21	8-15	1-7	.6-2

a/ Figures = % of total observations, N = about 2000 in 4 lecture or 4 lab periods per teacher (except T. nos. 6 & 7, N = about 4000 in double-period labs). N's for each teacher given in Tables 6 and 7.

b/ See text for complete definitions of categories and dimensions.

Teacher Talk = Sum of Categories 1,2,3,4,6,7,8,10 & 11
Teacher's Non-Verbal Behavior = Sum of Categories 5,9,12 & 13
Pupil Talk = Sum of Categories 14 & 15
Silence = Category 16

differences in time taken up by silent pauses in lecture classes was especially striking, but a discussion of the reasons for the difference can only be speculative and suggestive without additional contextual information and will, therefore, be taken up during a discussion of the interaction matrices.

5. Non-categorizable Behavior

During the second phase of the study, there were virtually no instances of behavior that were unclassifiable in the category system, and hence "category seventeen" will not be included in tables and figures or in further discussion. Suffice it to state that this may be viewed as at least a partial demonstration of the exhaustiveness of the present system.

The Major Dimensions of Teacher Behavior

The "average" teacher spent varying amounts of time in each of the three dimensions of teacher behavior as follows: Evaluative Dimension, 9 percent in lectures and 4 percent in labs; Cognitive Dimension, 54 percent in lectures and 42 percent in labs; Procedural Dimension, 18 percent in lectures and 40 percent in labs. In the ensuing pages, the major dimensions of classroom behavior will be discussed separately for analytical purposes while keeping in mind the underlying interrelatedness of the various "dimensions" of behavior. The order of presentation closely parallels the order in which the categories are listed. The reader may find it helpful to refer to the outline of the category system from time to time.

1. The Evaluative (Affective-Cognitive) Dimension

As shown in Table 9 the total evaluative behavior of the "average" teacher accounted for 9.4 percent of the time in lecture classes and 4.1

2. The Cognitive Dimension

As shown in Table 10, in the columns designated "Sum 5 to 9", an average of 42 to 54 percent of total class time was used in the pursuit of substantive information in biology labs and lectures respectively. The major portion of teacher behavior was devoted to information-giving as compared to information-seeking or having pupils give the information.

Substantive-information-giving behavior

As shown in Table 10, the average amount of time devoted to substantive information-giving (sum of categories 5 to 7) in lecture classes was 41 percent in lectures and 24 percent in labs. The individual scores of ten teachers ranged from 49 to 56 percent in lectures and 15 to 42 percent in labs. In lectures, however, an average of 42.5 percent, or virtually all of the information-giving behavior, was classified in category six, primarily verbal lecturing with an almost complete absence of demonstration, category five, or of substantive discussion, category seven. In labs the average of about 24 percent devoted to information-giving was made up largely of category six, 11.6 percent, and category seven, 11.4 percent. Only 1.4 percent of total laboratory time devoted to demonstration (category five).

Perhaps the most surprising finding in this study was the almost complete absence of demonstration, especially in lecture classes. Use of the most economical and widely held method of showing pupils how to find answers and relate to many demonstrations. It should be pointed out that the lecture figures of 1.4 percent and the highest figure of about 4 percent in lecture classes including the demonstration of techniques of using apparatus, etc., the individual scores of lecture demonstration, or time the figure for demonstration of classroom lecture was

percent in laboratory classes. The four categories of behaviors constituting the evaluative dimension -- teacher praises, teacher accepts, teacher corrects and teacher reprimands -- while considered to be extremely important in their effect on the social-emotional climate of the classroom, were the lowest in frequency of occurrence as compared to the two other dimensions of teacher talk. These findings are essentially in agreement with findings of other workers, but a feature that seems especially interesting is that the relative frequencies in categories one to four were higher in lecture classes than in laboratory classes. One would expect the contrary on the premise that the "situation" in laboratory classes is more evocative of evaluative responses. There is considerably more opportunity for individualized instruction and one to one interaction in laboratory classes and consequently for praise, acceptance, correction, etc. An interesting avenue of experimental research can be explored by systematically manipulating the amounts of the various evaluative behaviors, especially in the laboratory classes, and the consequent effects on affective and cognitive climate.

More than half of the total evaluative behavior in lectures and somewhat less than half in labs was classified in category two -- acceptance of pupils' responses and work. The other three categories occur with more or less equal frequency of about one percent.

An indication of the wide range in the frequencies or scores of each teacher in the four categories can also be obtained from Table V. Considerable differences between the lowest and highest scores are present. For example, the ratios of the highest to the lowest frequency vary from 1 in category three to 40 in category four for the lecture classes. The wide range of scores enhances their potential use for correlational and predictive purposes.

2. The Cognitive Dimension

As shown in Table 10, in the columns designated "Sum 5 to 9", an average of 42 to 54 percent of total class time was used in the pursuit of substantive information in biology labs and lectures respectively. The major portion of teacher behavior was devoted to information-giving as compared to information-seeking or having pupils give the information.

Substantive-information-giving behavior

As shown in Table 10, the average amount of time devoted to substantive information-giving (sum of categories 5 to 7) in lecture classes was 41 percent in lectures and 29 percent in labs. The individual scores of ten teachers ranged from 29 to 56 percent in lectures and 15 to 42 percent in labs. In lectures, however, an average of 42.5 percent, or virtually all of the information-giving behavior, was classified in category six, primarily verbal lecturing with an almost complete absence of demonstration, category five, or of substantive discussion, category seven. In labs the average of about 29 percent devoted to information-giving was made up largely of category six, 11.4 percent, and category seven, 11.4 percent. Only 1.4 percent of total laboratory time devoted to demonstration-lecturing [illegible]

Perhaps the most surprising finding in this study was the almost complete absence of demonstration, especially in lecture classes. This of the many measures used might appear to be the most important since it has been accompanied by many recommendations. It should be pointed out that the lecture figures of 41 percent and the laboratory figure of about 29 percent for substantive classroom information-giving behavior, are, in individual sessions as high as 56 percent and 42 percent, respectively, figures that

TABLE 8 RELATIVE FREQUENCIES OF SPECIFICITY INFORMATION GIVING AND INFORMATION SEEKING BEHAVIOR OF 7 PUBLIC TEACHERS IN LECTURE AND LABORATORY CLASSES a/

No.	4 Lectures per Teacher								4 Labs per Teacher							
	Category				Sum	Category		Sum	Sum	Category			Sum	Category		Sum	Sum
	1	2	3	4	1 & 2	1 to 3	5	6	7	5 to 7	8	9	8 & 9	5 to 9			
1	1.8	4.1	1.2	4.4	5.9	7.1	1.1	34.3	4.7	36.1	17.5	38.3	4.9	10.7	15.6	53.9	
2	1.4	5.1	1.1	2.1	6.5	7.6	1.1	33.4	1.8	30.3	3.1	42.2	8.4	1.9	10.3	52.5	
3	1.4	2.3	1.1	4.1	3.7	4.8	1.1	44.4	1.8	5.1	14.5	21.4	2.6	14.8	17.4	38.8	
4	1.4	5.1	1.1	2.1	6.5	7.6	1.1	27.4	1.7	13.5	12.1	28.3	9.0	4.6	13.6	41.9	
5	1.4	3.4	1.1	3.1	4.8	5.9	1.1	32.4	4.5	20.5	14.9	39.9	3.5	7.2	10.7	50.6	
6	1.4	3.1	1.1	3.1	4.5	5.6	1.1	34.1	1.8	9.3	11.5	26.1	4.3	4.3	8.6	34.6	
7	1.4	3.4	1.1	4.1	4.8	5.9	1.1	5.1	1.7	7.2	11.6	21.5	3.8	5.3	9.1	30.7	
8	1.4	2.1	1.1	2.1	3.5	4.6	1.1	41.5	2.2	4.5	7.2	14.9	2.5	23.0	25.5	40.4	
9	1.4	4.1	1.1	4.1	5.5	6.6	1.1	56.1	0.3	19.3	11.0	30.6	3.8	20.2	24.0	54.6	
10	1.4	3.2	1.1	3.1	4.6	5.7	1.1	57.1	1.1	20.5	15.3	36.9	3.8	2.7	6.5	43.4	
Mean	1.4	3.5	1.1	3.3	4.9	6.0	1.1	42.4	2.4	13.6	11.9	28.9	4.4	8.7	13.1	42.0	
Range	1-2	2-5	1-2	2-5	3-7	4-8	1-2	5-57	0-9	5-30	3-18	15-42	3-9	3-23	7-26	31-54	

a/ Figures = F for two observations, X = about 2000 for 4 lectures or 4 lab periods per teacher (except T. Nos. 1 & 2, X = about 4000 for double period labs). F's for each teacher given in Tables 6 & 7.

b/ Category 1 - Time Demonstration
Category 2 - Time Informative Information
Category 3 - Time Laboratory and Informative Directions
Category 4 - Time Asking Questions
Category 5 - Time at Desk & Work

whole class was lower. It is the writer's opinion that probably every science method course deals with the importance and techniques of good demonstrations. Parenthetically, this finding is highly suggestive that the teachers were not affected by the presence of the observer, at least to the extent of putting on a text-book model or show of teaching behavior. Assuming that the figures obtained in this study are valid, a number of questions come to mind. Would a similar study of a larger sample of biology teachers, observed more frequently, yield a similar percentage of behavior devoted to demonstrations? If so, how do biology teachers compare with other science teachers in the frequency and extent of demonstrations? The initial findings of an analytical study of 17 high school physics teachers by Snider (Personal Communication, 1965) indicate a similar low incidence of demonstrations in physics classes. Are demonstrations infrequently carried out because of lack of necessary preparation time? In high school biology teachers, and perhaps other science teachers in the "field" feel that demonstrations are really not of high value? Are demonstrations being replaced by films and other visual aids? Such other questions may be raised. The above questions are merely suggestive.

Summary of Observational Findings

This study indicates the feasibility of using direct observational and category systems to study teacher behavior. As shown in Table 10, the average score on this dimension was 11.4 minutes in lecture and 21.1 minutes in labs. We can say with confidence that more time in lecture classes, is devoted to demonstrations than in laboratory classes. It is interesting to speculate why the observations were not carried out. Is it because of lack of time? Is it because of lack of knowledge? Is it because of lack of interest? Is it because of lack of necessary

expected direction. However, relatively low frequency of category eight was unexpected in view of the greater opportunity for individualized interaction in laboratory classes. But, the low frequency of teacher questions provides some explanation, or at least is consistent with the low frequency in teachers' evaluative responses, shown earlier in Table 9, and the lower frequency of students' responses in labs -- shown in Table 15 and to be discussed more fully later.

Quasi-logical operations in information-giving

Four kinds of quasi-logical operations, namely: defining, fact stating and describing, explaining, and evaluating, are subsumed under category six, teacher gives substantive information. From Table 11 it can be seen that 42.3 percent of the total time in lecture classes and 13.5 percent of the total time in laboratory classes was used by the "average" teacher in giving substantive information. Clearly these figures, at the major premise, of the observations in category six was dichotomized more or less equally between fact stating and explaining in both lectures and labs. Defining and evaluating ranked third and fourth in order of magnitude among the logical operations. These findings are in general agreement with those reported by Bellack and Davitz (1963, p. 119).

From whose examination of Table 11, it may be seen that a majority of the beginners had a higher percentage score in fact stating (FS) than in explaining (EX). While the writer does not wish to pass judgment or engage in a discussion of the relative merits and demerits of giving facts versus explanations, a broader interpretive problem seems to exist. The writer's experience leads him to believe that many beginners probably think and believe that they give far more explanations than facts. Assuming this to be true, it would be of

TABLE 11 RELATIVE FREQUENCIES OF QUASI-LOGICAL OPERATIONS USED BY 10 BIOLOGY TEACHERS IN GIVING SUBSTANTIVE INFORMATION IN LECTURE AND LABORATORY CLASSES a/

T. No.	A Lectures per Teacher					A Labs per Teacher				
	Category Number b/				Sum	Category Number				Sum
	5D	6F	6X	6K	6D to 6K	6D	6F	6X	6K	6D to 6K
1	4.2	20.1	15.9	3.1	43.3	0.4	6.0	8.4	1.0	15.8
2	5.7	24.7	20.0	1.3	51.7	4.3	15.1	10.1	0.7	30.2
3	3.6	13.0	11.3	1.3	29.0	0.0	1.6	3.4	0.1	5.1
4	7.3	17.7	4.7	1.8	31.5	1.8	8.4	4.3	0.5	13.0
5	7.1	26.1	10.8	3.1	55.5	1.7	11.5	6.0	0.7	20.9
6	2.1	14.9	14.4	1.4	34.8	1.1	4.1	1.6	0.3	9.2
7	10.3	30.4	8.1	0.8	49.6	1.4	3.8	2.2	0.0	7.3
8	8.7	13.8	11.8	3.1	37.4	0.1	1.9	1.8	0.6	4.4
9	4.8	10.7	31.7	2.3	49.3	2.1	3.8	11.4	0.2	19.3
10	4.4	10.1	31.8	1.1	47.4	4.4	8.7	16.4	0.1	29.6
Avg.	5.4	18.4	16.8	1.8	44.4	1.8	6.8	5.4	0.4	13.5
Range	2.1-10.3	10.1-30.4	4.7-31.7	0.8-3.1	29.0-55.5	0.0-4.4	1.6-15.1	1.8-16.4	0.0-1.0	4.4-30.2

a/ Figures = % of total observations, N = times cited in 4 lectures or 4 labs per teacher (average 1 was 8 %), N = times cited in absolute serial total. N's for each teacher given in column 8 %.

b/ Categories 5D = F Definitions
5F = F Events
5X = F Explanations
5K = F Evaluations

interest to determine whether measurable changes in teacher behavior could be produced by using scores from interaction analysis as a means of feedback.

Table 11 shows that the "average" biology teacher spent about six percent of the total time giving definitions in lecture classes and less than two percent in laboratory classes. These scores appear to be rather low in view of the general comments of teachers and others, such as curriculum workers, that the vocabulary load is excessively burdensome in biology classes.

Of the four quasi-logical operations, the "average" biology teacher spent two percent of the total time in giving evaluations and opinions regarding subject matter in lecture classes and less than one percent in laboratory classes. The reader needs to recall that evaluations and opinions in category 8M are restricted to subject matter and not misbehavior of students. Present knowledge of the effect of such evaluations and opinions on pupil learnings is extremely limited. Highly speculative questions may be raised. What effect do the teacher's opinions and evaluations have on the attitudes of pupils toward and valuation of the subject matter? How are the teacher's statements and opinions, that go beyond the "scientific facts", about personal and social values and justifications of the subscientific knowledge of science related to the degree of personal and social relevance of science for the pupils?

Quantitative Comparisons in Different Topics

Category eight, teacher gets question, subsumes the same four logical operations of clarifying, fact stating, explaining and evaluating. From Table 12 it can be seen that in lecture classes, on the average, almost all of the 11.2 percent of time devoted to questioning is spent on those questions primarily directed toward clarifying, fact stating and explaining.

TABLE 12 RELATIVE FREQUENCIES OF QUASI - LOGICAL OPERATIONS USED BY 10 BIOLOGY TEACHERS IN SEEKING SUBSTANTIVE INFORMATION IN LECTURE AND LABORATORY CLASSES a/

T. No.	4 Lectures per Teacher Category Number b/				Sum	4 Labs per Teacher Category Number				Sum
	8D	8F	8K	8E	8D to 8E	8D	8F	8K	8E	8D to 8E
1	4.5	5.3	7.0	0.2	17.0	0.2	2.9	1.3	0.1	4.5
2	2.6	5.9	2.9	0.1	11.5	1.2	5.0	2.1	0.2	8.5
3	4.4	7.5	4.6	0.2	16.7	0.0	1.3	0.4	0.0	1.7
4	5.8	7.6	1.4	0.2	15.0	1.2	6.2	1.3	0.1	8.8
5	2.7	3.2	1.6	0.1	7.6	0.4	1.9	0.9	0.1	3.3
6	1.0	4.1	0.9	0.0	7.0	0.7	2.2	1.2	0.0	4.1
7	1.7	1.7	1.1	0.0	10.7	0.4	1.8	0.7	0.0	3.4
8	4.2	4.0	1.2	0.4	14.1	0.1	2.0	0.2	0.1	2.4
9	1.5	1.5	4.4	0.1	8.5	0.1	1.7	1.1	0.0	3.1
10	1.5	1.1	1.2	0.1	8.1	1.5	1.1	1.1	0.0	1.7
Ave	1.4	4.4	1.1	0.1	11.2	0.7	2.4	1.1	0.1	4.2
Range	1.5-4.5	1.1-7.6	0.9-7.0	0.0-0.2	7.0-17.0	0.0-1.2	1.1-6.2	0.2-2.1	0.0-0.2	1.7-8.8

a/ Figures in this table abbreviated, i.e. omitted 0 in the tenths or hundredths place (example: 1. means 0.1, .1 means 0.1, 1 means 1.0 or whole number). This was done to facilitate viewing the tables as a whole.

b/ Categories 8D - Data Supplied by Teacher
Categories 8F - Data Supplied by Other Persons
Categories 8K - Data Supplied by Materials
Categories 8E - Data Supplied by Equipment

while 0.1 percent, or virtually no time, was devoted to eliciting evaluative statements from pupils. Essentially the same pattern of time distribution prevailed in the laboratory classes with the exception that two to three times as many "fact questions" were asked compared to requests for explanations and definitions. In the laboratory these "fact questions" were largely questions about the results obtained as pupils carried out the various steps of laboratory directions.

In comparing the relative frequencies of each of the quasi-logical processes in information-giving (Table 11) with those in information-seeking (Table 12), it seems reasonable to infer that teachers ask pupils to give definitions more often than facts or explanations. For instance, in lectures, the average teacher gave definitions 5.2 percent of the time and asked pupils for definitions 3.4 percent of the time; whereas the average teacher gave explanations 15.2 percent of the time, but asked pupils to give explanations only 1.1 percent of the time. Earlier in the discussion, it was pointed out that in view of the heavy vocabulary load in biology, the "average" teacher spent very little time, less than six percent, in giving definitions. While the additional information mentioned above provides more perspective, it raises another point. If we assume the soundness of the popular notion -- (1) pupils study most that which the teacher asks for most of the time, and (2) the types of questions that teachers ask are a reflection and a signal of what the teacher considers important -- then it would be reasonable to suppose that the pupils' image of mastery of biological science would be isomorphic to that of the teacher vis-a-vis the responsibilities of biological terms. A critically significant area of research in the more subtle personal and attitudinal effects of teachers' questions is worthy of further investigation.

References to the Nature of Science

The teachers and pupils observed in this study made very few (average of less than 0.1 percent) explicit references to the nature and processes of science in lecture or laboratory classes. The data were presented in Tables 6 and 7 and will not be presented separately. References to the nature of science occurred in the classes of four of the ten teachers, and the highest frequency of occurrence was about 0.3 percent.

In view of the current emphasis on the nature and processes of science as an essential aspect of "modern" curricula and the commonly mentioned objective of teaching scientific methods in the "traditional" courses, one is challenged by the wide discrepancy between stated goals and classroom practice. It may be argued that the nature of science is communicated implicitly rather than explicitly, that "somehow" students learn about the role and nature of various scientific processes of observation, measurement, hypothesizing, theorizing, model-constructing and so on. The writer's objection to such an argument can be stated very simply. The primary goal of science teaching should not be left to chance, and its achievement cannot be explained away by saying that pupils learn about the nature of science "somehow" by some mysterious unobservable process. Another argument may be advanced that the categories in the system are not valid for categorizing behaviors designed to teach the nature of science or that the observer failed to record such behavior. A number of points mitigate this argument. First, the observer was especially alert to manifestations of these behaviors which occurred infrequently. Second, the categories purporting to classify the verbal communications about the nature of science are extremely broad and global, by definition, so as to be inclusive and exhaustive

of such behaviors or statements rather than specific or preclusive. Their validity, or at least their face validity, seems high. Third, categories 7S and 8P which categorize teacher behavior devoted to stimulating pupils toward problem solving, experimentation and trying of original solutions, had extremely low frequencies. Average frequencies of occurrence were less than 0.1 percent for category 7S and 0.3 percent for category 8P in both lectures and labs. These low frequencies are logically consistent with the low frequencies in the nature of science categories, 6N and 8N, 14N and 15N; and hence strengthen the writer's confidence in the validity of the categories. Fourth, the initial findings of a study of 17 Physics teachers by Snider (Personal Communication, 1965) indicate a similar low frequency of verbal references to the nature of science.

If, on the other hand, we accept the conclusion contingent upon further evidence, that very few, if any, references are made in science classes regarding the nature of science as compared to the products or facts, concepts and principles of science, then serious consideration must be given to how the change in teacher behavior can be accomplished, if such changes are to be sought.

3. The Procedural Dimension

"Procedural" and managerial behaviors claimed an average of 18 percent of the total time in lecture classes and 41 percent of the total time in laboratory classes. As shown in Table 13, the average scores for the total of four categories in this dimension ranged from about 14 to 28 percent in lectures and about 34 to 50 percents in laboratories. It is noteworthy that the "average" teacher in laboratory classes spent about the same amount of time, 42 percent, in the cognitive domain as in the procedural domain. In lecture and labs about 12 percent of the

TABLE 13 RELATIVE FREQUENCIES OF PROCEDURAL BEHAVIORS OF 10 BIOLOGY TEACHERS IN LECTURE AND LABORATORY CLASSES a/

T. No.	Δ Lectures per Teacher					Δ Labs per Teacher				
	Category Number b/				Sum	Category Number b/				Sum
	10	11	12	13	10 to 13	10	11	12	13	10 to 13
1	1.2	10.5	1.2	0.0	13.7	3.7	7.5	10.9	8.9	31.0
2	0.2	8.7	2.0	0.0	11.9	2.2	10.7	8.2	4.3	25.4
3	0.9	5.9	1.6	4.4	12.8	1.8	8.2	25.7	10.0	45.7
4	3.0	12.7	1.9	0.3	17.5	3.5	11.8	10.5	4.6	30.4
5	1.4	11.9	1.4	0.1	14.8	1.8	14.3	16.1	0.3	32.5
6	2.0	14.4	12.0	0.0	28.4	2.2	14.5	30.5	3.9	45.1
7	1.1	10.5	5.3	0.0	16.9	1.0	14.0	10.0	10.5	36.3
8	2.3	11.2	3.8	0.8	18.0	1.3	8.5	13.0	13.2	36.0
9	1.0	13.0	2.5	0.3	16.8	2.5	5.8	14.4	14.4	37.0
10	1.3	14.6	2.1	0.4	18.4	1.3	21.0	12.9	3.4	38.6
Ave	1.5	11.7	3.0	0.8	17.0	2.2	12.4	17.4	7.2	38.4
Range	.2-3.0	5.9-14.6	1.2-12	0-4.4	11.9-28.4	1.0-3.7	5.8-21.0	8.2-30.5	0-14.4	25.4-45.7

a/ Figures = % of total observations; N = about 600 in lectures or 400 in labs per teacher (except T. nos. 4 & 7, N = about 800 in combined-period labs). N's for each teacher given in Table 1 & 2.

b/ Category 10 = Asks questions or makes statements
Category 11 = Gives information
Category 12 = Attends to individual or group behavior
Category 13 = Interacts in unspecified ways or is out of room

time was spent in giving routine directives, assignments, etc. (category eleven). The comparatively greater time spent in the procedural dimension in labs was mostly due to behaviors classed under category twelve, attending to routine tasks (15.5 percent), and category thirteen, supervision of laboratory work (9.6 percent).

The procedural dimension or behavior devoted to classroom routines, mechanics or management, as it has been variously called, has not received as much attention as the affective and cognitive dimensions in the various category systems developed for studying classroom interaction. The study by Bellack and Davitz (1963) was a noteworthy exception in this case. Whether this neglect reflects an implicit assumption that "routine" behaviors are not important in research on teacher behavior, or merely unexciting as an area of research cannot be stated. However, it seems highly probable that the ways in which classroom routines are managed would have at least some effect on the affective and cognitive climate of the classroom. For instance, does a higher frequency of statements that provide orientation and explicate transition from one topic to the next result in greater clarity of presentation and less confusion and frustration? In the present category system, the categories in the procedural dimension were not further subdivided, but further subdivision would be feasible at a future time.

4. Pupil-Talk Dimension

Approximately 15 percent of total observations were categorized under the pupil-talk dimension. In lecture classes, pupils' questions comprised less than a fourth of total pupil talk, but in laboratories, pupils' questions comprized about half of the pupil talk (data in Tables 6 and 7).

Before considering the various sub-categories, the reader is

reminded that much of the pupil talk was extremely difficult to hear, and consequently greater inference was used in categorizing on the basis of partially heard questions and responses, as described in the ground rules of the category system. Hence the writer feels less confident than he would wish to be about the frequencies of the various subdivisions of pupil talk reported in Tables 14 and 15.

Pupils' information-seeking behavior

As shown in Table 14, an average of 2.6 percent of the time in lecture classes was spent by pupils in asking questions, and 1.2 percent or about half of that time, was used in seeking explanations. By contrast, about two-thirds, or 4.6 out of 6.3 percent of the time in laboratory classes was used by the "average" pupil in asking for procedural assistance (category 14A).

If we interpret pupil questions as requests for clarification, we may be able to construct some indices of the clarity with which the teacher gave definitions, explanations, directions, etc. On the other hand, if we interpret pupil questions as evidence of interest, an intriguing possibility of measuring pupil interest could be explored. However, it is more likely that pupil questions are motivated by a number of reasons. Improvements in the technology and techniques of recording are needed before pupils' questions can be clearly recorded, reliably scored and studied in detail.

Pupils' information-giving behavior

As shown in Table 15, approximately half of all pupil responses in lecture and laboratory classes were classified under category 15F, pupil gives facts. Moreover, if the average frequencies of the various kinds of teacher questions are compared to the various kinds of pupil responses, one finds a close parallel. Bearing in mind the limitations

TABLE 14 RELATIVE FREQUENCIES OF PUPILS' QUESTIONS IN LECTURE AND LABORATORY CLASSES OF 10 BIOLOGY TEACHERS a/

T. No.	4 Lectures per Teacher					4 Labs per Teacher				
	Category Number b/				Sum	Category Number				Sum
	14D	14F	14X	14A	14D to 14A	14D	14F	14X	14A	14D to 14A
1	0.1	0.4	0.4	0.2	1.1	0.1	0.2	0.5	3.8	4.6
2	0.4	0.4	1.1	0.4	2.3	0.8	1.1	0.5	0.8	3.2
3	0.0	0.5	1.2	0.2	1.9	0.0	0.2	0.2	6.7	7.1
4	0.2	0.9	0.3	0.2	1.6	0.1	0.4	0.4	1.9	2.8
5	0.1	0.1	0.3	0.5	1.0	0.2	0.5	0.5	4.6	5.8
6	0.2	0.9	2.9	0.8	4.8	0.4	1.8	1.2	5.6	9.0
7	0.3	1.6	0.4	1.1	3.4	0.2	1.3	0.3	7.6	9.4
8	0.1	0.1	0.0	0.1	0.3	0.2	0.2	0.1	3.3	3.8
9	0.3	1.2	3.3	1.2	6.0	0.2	0.1	0.7	1.8	2.8
10	0.3	0.4	1.3	0.8	2.8	0.3	1.2	1.3	5.4	8.2
Ave.	0.2	0.6	1.2	0.6	2.6	0.3	0.8	0.6	4.6	6.3
Range	0-.4	.1-1.6	0-3.3	.2-1.2	.3-6	0-.8	.1-1.8	.1-1.3	.8-7.6	2.8-9.4

a/ Figures = % of total observations, N = about 2000 in 4 lectures or 4 labs per teacher (except T. nos. 6 & 7, N = about 4000 in double period labs). N's for each teacher given in Tables 6 & 7.

b/ Category 14D - P Asks Teacher to Define Terms
Category 14F - P Asks Teacher to State Facts
Category 14X - P Asks Teacher to Explain
Category 14A - P Seeks Assistance, Asks for Directions

TABLE 15 RELATIVE FREQUENCIES OF PUPILS' RESPONSES IN LECTURE AND LABORATORY CLASSES OF 10 BIOLOGY TEACHERS a/

T. No.	4 Lectures per Teacher					4 Labs per Teacher				
	Category Number b/				Sum	Category Number				Sum
	15D	15F	15X	15R	15D to 15R	15D	15F	15X	15R	15D to 15R
1	2.9	3.6	3.5	0.2	10.2	0.1	3.9	0.8	1.5	6.3
2	1.6	5.4	2.5	0.1	9.6	1.1	5.0	2.0	1.4	9.5
3	4.5	6.5	5.3	0.3	16.6	0.0	2.3	0.7	1.0	4.7
4	6.0	10.0	1.5	0.9	19.4	1.4	10.7	1.4	2.4	15.9
5	2.9	3.2	1.3	0.7	8.4	0.4	3.0	0.8	1.6	6.1
6	2.4	9.3	1.5	1.2	14.4	0.7	3.0	1.2	0.7	5.6
7	2.6	5.6	2.4	0.2	10.8	0.6	2.4	0.6	0.5	4.1
8	4.9	4.0	2.0	0.4	11.3	0.2	2.3	0.4	2.7	5.6
9	1.9	1.7	5.2	0.8	9.6	0.2	2.1	0.7	1.5	4.5
10	1.4	2.8	3.6	0.4	8.2	1.1	1.2	0.9	0.8	4.0
Ave.	3.1	5.1	2.9	0.5	11.6	0.6	3.3	0.9	1.3	6.1
Range	1.4 -6	1.7-10	1.3-5.3	.1-1.2	8.2-19.4	0-1.4	1.2-10.7	.4-2	.5-2.7	4-15.9

a/ Figures = % of total observations, N = about 2000 in 4 lectures or 4 labs per teacher (except T. nos. 6 & 7, N = about 4000 in double period labs). N's for each teacher given in Tables 6 & 7.

b/ Category 15D - P Defines Terms
Category 15F - P States Facts
Category 15X - P Explains
Category 15R - P Gives Information Regarding Assignments

of the data, these findings are consistent with one of the assumptions stated in the theoretical rationale of this study, namely, the pupil gives or tends to give the kinds of answers that the teacher seeks. It seems reasonable to propose that the kind of cognitive climate prevailing in a classroom may be affected and even controlled by the kinds of questions asked by teachers.

Teacher-pupil interaction in high school biology classes has been discussed at some length in the foregoing pages. The various categories and dimensions were discussed separately for analytical purposes. However, such a procedure results in the fragmentation of an intricately inter-related phenomenon. In an attempt to recapture the "whole picture" and by way of a summation, two "interaction profiles" are shown in Figure 2. The various scores in the two profiles are percentages of the total of 20,122 observations in 40 lecture periods, and 24,046 observations in 48 laboratory periods respectively (the data were previously shown in Tables 6 and 7). The marked differences in the relative frequencies of the various categories and the differences in the two profiles can be readily seen.

CATEGORY	
T. Praises	1
T. Accepts	2
T. Corrects	3
T. Reprimands	4
T. Demonstrates	5
T. Defines	6D
T. States Facts	6F
T. Explains	6X
T. Gives Evaluations	6E
T. Gives Info. Nat. of Sci.	6N
T. Lacks Information	6L
T. Gives Info. (Sum of 6's)	
T. Gives Lab Directions	7
T. Asks for Definitions	8D
T. Asks for Facts	8F
T. Asks for Explanations	8X
T. Asks for Evaluations	8E
T. Asks Ques. Nat. of Sci.	8N
T. Asks Prob. Solving Ques.	8P
T. Asks Info. (Sum of 6's)	
T. Looks at P's Work	9
T. Asks Procedural Quest.	10
T. Gives Procedural Direct.	11
T. Attends to Routine	12
T. Supervises	13
P. Asks for Definitions	14D
P. Asks for Facts	14F
P. Asks for Explanations	14X
P. Asks for Evaluations	14E
P. Asks Quest. Nat. of Sci.	14N
P. Asks for Assistance	14A
P. Asks for Info. (Sum of 14's)	
P. Defines	15D
P. States Facts	15F
P. Explains	15X
P. Gives Evaluations	15E
P. Gives Info. Nat. of Sci.	15N
P. Lacks Information	15L
P. Gives Prob. Solving Info.	15P
P. Gives Routine Info.	15R
P. Gives Info. (Sum of 15's)	
Silence	16

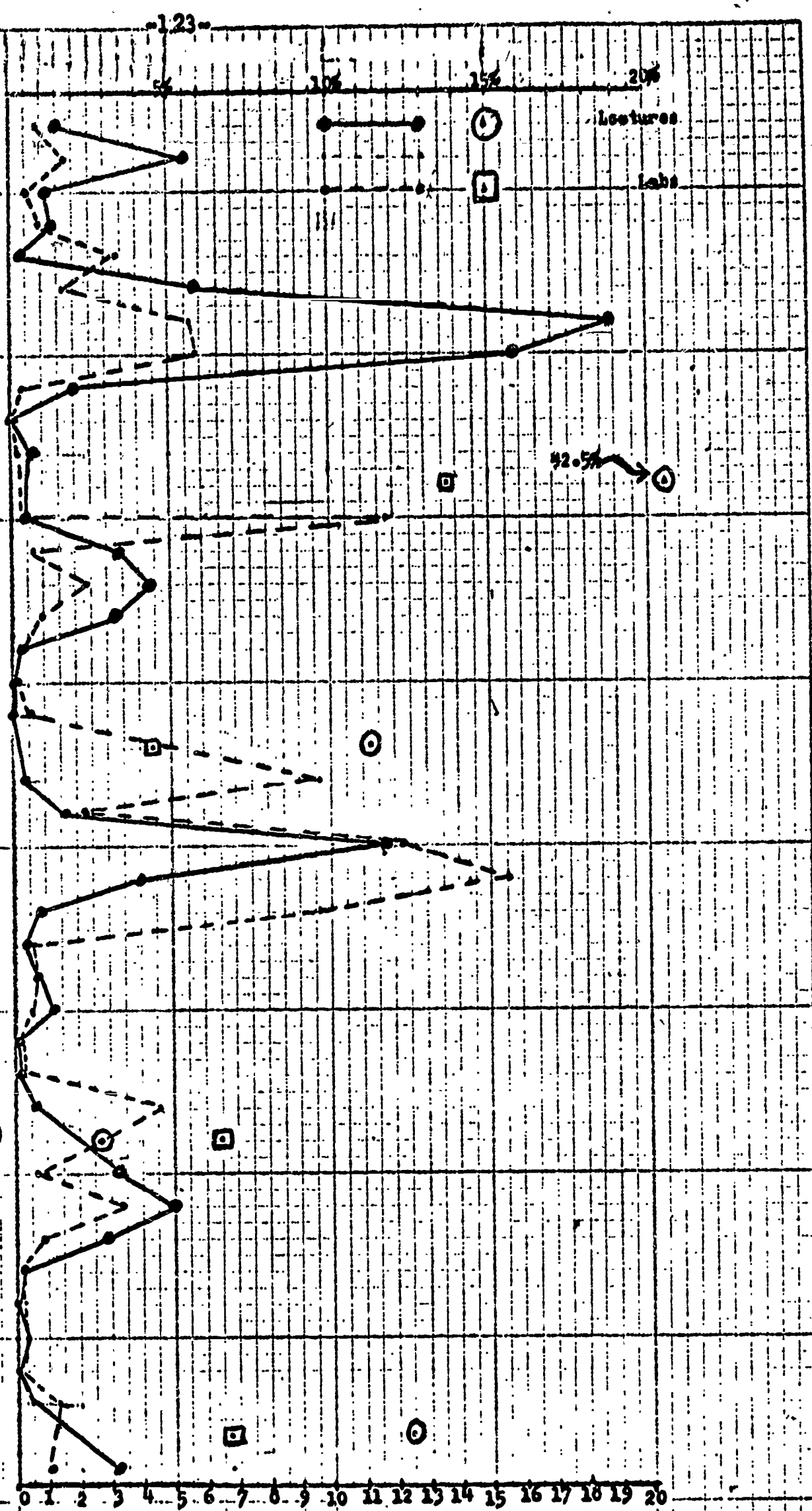

FIGURE 2 PROFILES OF TEACHER-PUPIL INTERACTION IN BIOLOGY LECTURE AND LABORATORY CLASSES

Analysis of Interaction Matrices

Before proceeding to an analysis of the matrices, some guide lines will be provided for readers having a limited familiarity with such analysis. A more detailed treatment of matrix analysis can be found in Amidon and Flanders (1963), and Flanders (1964 a, 1964 b).

The major feature of an interaction matrix is that it can be used for studying and analyzing behavioral sequences and patterns of interaction. The analysis yields a more "dynamic" model of teacher-pupil interaction as compared to the "static" model derived from frequency distributions. An interaction matrix can be analyzed at varying levels of detail ranging from large areas of the matrix to individual cells. The large areas of the interaction matrix, composed of groups or blocks of cells, represent either a single dimension of behavior or an intersection of any two dimensions of behavior. The present category system has five major dimensions and hence 5x5 areas in the matrix, as shown in Figure 3. Each cell in a matrix represents a temporal sequence of a pair of behavioral acts. For "N" categories there are "NxN" cells each representing a possible sequence or "temporal behavior-pair". The reader may recall that the classroom observational record is a series of category numbers written every five seconds (or less) in the sequence in which the behavior occurred. The series of numbers are plotted or entered into a matrix two at a time. The first number of each pair is entered in the appropriate row of the matrix, and the second number of the pair consists of the first two numbers in the observational record. The second pair consists of the second and third numbers and thus overlaps the preceding pair, and so on. All entries in the matrix are made from a series of overlapping pairs of (category) numbers.

		E				C					R				P		S	
Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1																	
T. Accepts P's Response	2								*				*			*	*	
T. Corrects P's Response	3		E	E	**			E	C			E	R		E	P	ES	
T. Reprimands Pupil(s)	4																	
T. Demonstrates	5																	
T. Gives Substantive Info.	6																	
T. Gives Lab. Directions	7		C	E *				C	C **			C	R *		C	P *	CS*	
T. Seeks Substantive Info.	8																	
T. Looks at P's Work	9																	
T. Asks Procedural Ques.	10																	
T. Gives Procedural Direc.	11		R	E *				R	C *			R	R **		R	P *	RS*	
T. Attends to Routines	12																	
T. Supervises	13																	
P. Seeks Information	14		P	E *				P	C *			P	R *		P	P **	PS*	
P. Gives Information	15																	
Silence	16		S	E *				S	C *			S	R *		S	P *	SS**	
Total in Each Category																		

FIGURE 3 16x16 INTERACTION MATRIX SHOWING GROUPING OF 256 CELLS INTO 25 AREAS. *"Transitional areas indicate change in behavior from one "dimension" of the category system to another. **"Steady state areas" indicate sustained behavior within a single "dimension".

The basic rule for "reading" an interaction matrix can be stated thus: To determine the sequence of a pair of behaviors always "read" the horizontal row designation first and the vertical column designation next. For instance, in the 16x16 matrix, the cell 8-15 should be read as row 8, column 15 and represents the sequence teacher asks question -- pupil gives answer; the cell 15-3, i.e., row 15, column 3, represents the sequence pupil gives information -- teacher corrects pupil's response; the cell 6-6, i.e., row 6, column 6 represents the sequence teacher gives substantive information followed by teacher gives more substantive information.

In a similar manner, depending on the purpose of a study, the several rows and columns within a dimension can be treated as units for analysis of large blocks or areas of the matrix. These units are designated by the letters E,C,R,P, and S in Figure 3 and stand for the "Evaluative," "Cognitive," "Procedural or Routine," "Pupil-Talk" and "Silence" dimensions respectively. Thus area EE represents evaluative statements followed by evaluative statements. Area EC represents evaluative statements followed by substantive statements in the "Cognitive Dimension" and so on. Thus, by looking at these areas in a matrix, relative distribution of interaction in the major dimensions can be readily ascertained.

Within each area, or in the interaction matrix for that matter, two kinds of cells can be distinguished, namely, the steady-state cells and the transitional cells. The steady-state cells are found along the diagonal formed by the cells having the same row and column designations, such as 1-1, 2-2, 3-3, 6-6, 11-11, 16-16. Entries in these 16 steady-state cells, in a 16x16 matrix, indicate that the same kind or category of behavior persisted for more than one time unit, i.e., longer than

five seconds. Certain types of teacher talk -- such as lecturing, giving directions -- typically last for more than 5 seconds without interruption, and hence one may expect a higher number of entries in certain steady-state cells. Transitional cells have unlike row and column designations, such as 1-2, 1-3, 2-3, 8-16. Transitional cells indicate a transition or change or shift from one kind or category of behavior to another.

The analysis of matrices will be confined to two 16x16 "grand" matrices (Figures 4 and 8) and two 31x31 "grand" matrices (Figures 6 and 10). The "grand" lecture matrices were plotted from all of the 20,122 observations recorded in the 40 lecture periods of all 10 teachers. The "grand" laboratory matrices were plotted from all of the 24,046 observations recorded in the 48 laboratory periods of 10 teachers. Hence, these grand matrices will be used to develop a descriptive model of the "average" teacher analogous to that developed (in the preceding section) from the percentage scores of the "average" teacher. The 16x16 lecture and laboratory matrices of individual teachers based on four lectures or four labs are placed in the Appendix. Readers interested in detailed information about each teacher and the many individual differences among various teachers are invited to study these matrices.

A slight digression is needed to explain how the 31x31 matrices were prepared. The reader may recall that the 1604 computer was used to plot various 16x16 and 44x44 matrices. The 44x44 matrices proved to be extremely unwieldy (44 rows, 44 columns and 1936 cells). Upon close examination, the 44x44 matrices were found to contain many rows and columns having a total of 0.1 percent or fewer entries. Hence, in the interest of intelligibility, the writer (manually) transformed the two 44x44 grand matrices to two 31x31 grand matrices, one for 40 lecture periods (Figure 6) and the other for 48 laboratory periods (Figure 10).

The 31x31 matrices were prepared by pooling or combining sub-categories for which there were very few entries in the matrix, about 0.1 percent or less. The summed or pooled categories are designated on the 31x31 matrix as 6+, 7+, 8+, 14+, and 15+. Those sub-categories that were not pooled appear on the matrix as originally defined in the category system. For instance, category six has sub-categories designated as 6D, 6F, 6X, 6E, 6N, 6L, and (a residual) 6U. In the 31x31 matrices 6D, 6F, 6X, and 6E are tabulated as rows and columns but 6N, 6L and 6U have been summed or combined and designated as 6+. Similarly, 7+ is a summation of 7, 7C and 7S; 8+ is a summation of 8E, 8N, 8P, and 8U; 14+ is a summation of 14E, 14N, and 14U; and 15+ is a summation of 15E, 15N, 15L, 15P, and 15U.

The percentage figures in the cells in all matrices reported in this study have been rounded to 0.1 percent. An "empty" cell in the matrix indicates either a complete absence of the particular sequence of behavior or an occurrence of 0.05 percent or less. This slight loss of information and accuracy is counter balanced by the gain in readability of the matrices.

Analysis of Lecture Matrices

The most striking entry in the 16x16 "lecture matrix" (Figure 4) is that 33 percent of all entries are in the 6-6 cell, indicating sustained substantive information-giving or "lecturing." At various times the "average" teacher shifted from lecturing to asking questions, as indicated by the figure of 3.7 percent in the 6-8 cell. To a lesser extent, the teacher shifted to giving directions, orientation, explicating transitions, etc., as indicated by the figure of 1.9 percent in the 6-11 cell. In decreasing order of occurrence the teacher moved from lecturing to procedural questions, 6-10 cell, praise, and acceptance of

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1	.3					.3		.2			.2				.3		
T. Accepts P's Response	2	.1	.5	.1			2.2		1.6		.1	.4			.1	.2	.1	
T. Corrects P's Response	3		.1	.1			.3		.3			.1				.2		
T. Reprimands Pupil(s)	4				.6		.1		.1			.2				.1		
T. Demonstrates	5						.1											
T. Gives Substantive Info.	6	.3	.1		.1	.1	33		3.7		.4	1.9	.1		1.1	.6	.3	
T. Gives Lab. Directions	7							.2										
T. Seeks Substantive Info.	8						.5		2.5			.2			.2	6.4	1.2	
T. Looks at P's Work	9									.2								
T. Asks Procedural Ques.	10						.2		.1		.1	.2			.1	.6	.1	
T. Gives Procedural Direc.	11	.1			.2		1.7		.7		.3	6.8	.5		.4	.7	.4	
T. Attends to Routines	12						.1		.1		.1	.4	3.3		.1			
T. Supervises	13													.6				
P. Seeks Information	14		.1	.1			1.3		.1		.1	.5			.5			
P. Gives Information	15	.5	4.7	.9	.2		1.2		1.1		.3	.7			.1	2.4	.1	
Silence	16	.1			.1		.4		.7		.1	.4	.1		.1	.5	.9	
Total in Each Category		1.4	5.5	1.2	1.2	0.1	42.4	0.2	11.2	0.2	1.5	12.0	4.0	0.6	2.7	12.0	3.1	99.3

FIGURE 4 16x16 INTERACTION MATRIX BASED ON 40 LECTURE PERIODS OF 10 BIOLOGY TEACHERS. Figures in cells = % of 20,122 observations, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15-3 is read as P Gives Information and T Corrects P's Response. (Column totals do not add up to 100% due to rounding).

feelings of pupils, 6-1 cells, and even less frequently to acceptance of student ideas, reprimands, demonstrations, attention to routines, and silent pauses, as can be seen by the figure of 0.1 percent in each of cells 6-2, 6-4, 6-5, 6-12, and 6-16 respectively. Occasionally, 1.1 percent in the 6-14 cell, pupils "interrupted" or interacted by asking questions and less often, 0.6 percent, by statements that were probably "spontaneous." By looking at the intersection of each row with the cells in column 6, we can determine the types of behaviors that preceded the teacher's lecturing or information-giving behavior. The most frequent behaviors preceding lecturing (besides previous lecturing) were those in category two (row two), accepting pupils' response, 2.2 percent in the 2-6 cell. Less frequently, lecturing was preceded by the following behaviors: (1) procedural directions, 1.7 percent in the 11-6 cell, (2) pupil's information-seeking, 1.3 percent in the 14-6 cell, (3) pupil's information-giving, 1.2 percent in the 15-6 cell. On occasion the teacher literally answered his own questions, (teacher questions preceded lecturing) 0.5 percent in the 8-6 cell and 0.2 percent in the 10-6 cell. The figures mentioned above convey some idea of the frequency of occurrence of the more common "categories" of behavior preceding or following the predominant behavior, i.e., lecturing. However, it is difficult to see any pattern or regularity of events in the foregoing paragraph. Hence, the next step in the analysis of the matrix consists of formulating the most common pattern(s) discernible in the classroom behavior of the "average" biology teacher in lecture classes.

In Figure 5 the most common pattern of behavioral acts is shown. The figure in each cell is the percentage of total observations and has been transcribed from Figure 4 -- the 16x16 Interaction Matrix of 40

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1																	
T. Accepts P's Response	2						2.2											
T. Corrects P's Response	3																	
T. Reprimands Pupil(s)	4																	
T. Demonstrates	5																	
T. Gives Substantive Info.	6						33*		3.7									
T. Gives Lab. Directions	7																	
T. Seeks Substantive Info.	8								2.5							6.4		
T. Looks at P's Work	9																	
T. Asks Procedural Ques.	10																	
T. Gives Procedural Direc.	11																	
T. Attends to Routines	12																	
T. Supervises	13																	
P. Seeks Information	14																	
P. Gives Information	15															2.4		
Silence	16																	
Total in Each Category																		

FIGURE 5 THE MOST COMMON PATTERN OF BEHAVIOR IN BIOLOGY LECTURE CLASSES. Figures in cells are percentages taken from Figure 4. The "unbroken arrows" indicate the sequence 6-6* --> 6-8 --> 8-15 --> 15-2 --> 2-6. See Text.

lectures. The pattern shown in Figure 5 can be translated to provide a word "picture" or description. If an observer walked into the "average" biology lecture class, he would probably find the following pattern: The teacher would be giving substantive information or lecturing, 6-6 cell. After a few seconds, or more likely after a few minutes, the teacher would ask a short question lasting less than five seconds, 6-8 cell. Sometimes the question would last longer than five seconds, 8-8 cell. Most of the time a pupil would respond to the question by using a word or a phrase or a short sentence, 8-15 cell. Occasionally, the pupil would respond for longer than five seconds, 15-15 cell. Next, the teacher would give an evaluation of the pupil response, most often an acceptance or indication that the response was correct, 15-2 cell. Following the evaluation, the teacher would give more substantive information, 2-6 cell, and continue lecturing, 6-6 cell, for the next few minutes. The reader may note that only 7 out of a total of 256 cells in the matrix are used to describe the most common sequence of events and the entries in these 7 cells account for about 55 percent of the total interaction. These events occurred repeatedly to form the dominant pattern. This basic pattern of information-giving and information-seeking may be summarized as follows: Teacher lectures for a relatively long period of time ——→Teacher asks question ——→ Pupil responds ——→Teacher accepts response ——→Teacher lectures.

The next level of analysis entails a study of the 31x31 lecture matrix for a closer look at the above pattern and at the quasi-logical operations subsumed under the rubrics of information-giving and information-seeking. The reader may recall the 31x31 matrix contains the most commonly occurring sub-categories of 6, 8, 14, and 15.

The teacher's information-giving behavior or lecture was characterized by relatively stable monologues varying in duration from a few seconds to a few minutes. The three most common types of monologues were fact stating and describing, explaining, and defining, while evaluation of subject matter occurred infrequently. Within the area or block of 16 cells bounded by 6D, 6F, 6X and 6E in Figure 6, the three steady-state cells, namely, 6D-6D (3.2 percent), 6F-6F (12.5 percent) and 6X-6X (11.4 percent) constituted 27.1 percent out of the total of 33 percent in all 6-6 cells. The transitional cells, such as 6D-6F, 6F-6X had relatively lower frequencies of about one half to one percent. It can be inferred that information-giving consisted primarily of relatively discrete and unmixed "packets" of definitions, or facts, or explanations, or evaluations, with relatively little, albeit some, mixing or shifting from one information-giving quasi-logical operation to another. Occasionally, the teacher shifted from lecturing to asking questions, and this step in the sequence can be seen in the groups of the various 6-8 and 8-8 cells in Figure 6. Even within this shift or transition a certain regularity was discernible in the teacher's behavior. Definition giving, 6D, was followed about three times more often by definition seeking, 8D, than by either fact seeking, 8F, or explanation seeking, 8X. Giving facts, 6F, was followed about twice as often by fact seeking, 8F, as compared to either definition seeking, 8D, or explanation seeking, 8X. Similarly, giving explanations, 6X, was followed about twice as often by explanation seeking, 8X, as by definition or fact seeking, 8D or 8F. In brief, a specific kind of quasi-logical operation used in information-giving was followed more frequently by the teacher's solicitation of the same kind of quasi-logical operation. Whether such a solicitation was of short or long

CATEGORY		1	2	3	4	5	6+	6D	6P	6X	6E	7+	8+	8D	8P	8X
T. Praises	1	.2							.2	.1				.1	.1	.1
T. Accepts	2	.1	.5	.1				.4	1.0	.8	.1			.5	.7	.4
T. Corrects	3			.1				.1	.1	.1				.1	.1	
T. Reprimands	4				.6				.1						.1	
T. Demonstrates	5							.1								
T. Gives Information	6+						.1									
T. Defines	6D					.1		3.2	.6	.4				.3	.1	.1
T. States Facts	6P	.1					.1	.6	12.5	1.3	.4			.5	1.0	.4
T. Explains	6X	.1						.3	1.0	11.4	.2			.2	.3	.5
T. Gives Evaluations	6E								.4	.2	.9				.1	
T. Gives Lab. Directions	7+											.2				
T. Seeks Information	8+															
T. Asks for Definitions	8D							.1						.7		
T. Asks for Facts	8P								.2						.7	
T. Asks for Explanations	8X									.1						1.0
T. Looks at P's Work	9															
T. Asks Procedural Questions	10							.1	.1							
T. Gives Procedural Directions	11	.1		.2				.3	1.0	.3	.1			.3	.3	.1
T. Attends to Routines	12								.1							
T. Supervises	13															
P. Seeks Information	14+															
P. Asks for Definitions	14D							.1								
P. Asks for Facts	14P								.4							
P. Asks for Explanations	14X									.5						
P. Asks for Assistance	14A								.1							
P. Gives Information	15+		.1		.1											
P. Defines	15D	.1	1.5	.3				.1						.2	.1	
P. States Facts	15P	.2	2.0	.4					.4	.1				.1	.3	.1
P. Explains	15X	.1	1.2	.2						.2						.2
P. Gives Routine Information	15R															
Silence	16	.1			.1			.1	.2	.1				.1	.3	.2
Total in Each Category		1.1	5.3	1.1	1.2	.1	.2	5.2	18.6	15.6	1.7	0.2	0	3.1	4.1	3.0

FIGURE 6 FLANDERS INTERACTION MATRIX BASED ON 40 LECTURE PERIODS OF 10 BIOLOGY TEACHERS. Figures in cells = % of 20,122 observations, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15P-2 is read as P States Facts and T Accepts.

CATEGORY		9	10	11	12	13	14	14D	14F	14X	14A	15	15D	15F	15X	15R	16
T. Praises	1			.2										.1	.1		
T. Accepts	2		.1	.4									.1	.1			
T. Corrects	3			.1									.1	.1			
T. Reprimands	4			.2													
T. Demonstrates	5																
T. Gives Information	6+																
T. Defines	6D			.4													.1
T. States Facts	6F		.1	.7					.2	.1	.2			.2			.1
T. Explains	6X		.2	.6					.1	.4					.1		.1
T. Gives Evaluations	6E			.1						½							
T. Gives Lab. Directions	7+																
T. Seeks Information	8+											.1					
T. Asks for Definitions	8D			.1								.1	1.9				.4
T. Asks for Facts	8F			.1								.1		2.7			.4
T. Asks for Explanations	8X			.1								.1			1.5		.4
T. Looks at P's Work	9	.2															
T. Asks Procedural Questions	10		.1	.2								.1		.1		.4	.1
T. Gives Procedural Directions	11		.3	6.5	.5					.1	.3	.1	.1	.4	.1		.4
T. Attends to Routines	12		.1	.4	3.2												
T. Supervises	13					.6											
P. Seeks Information	14+																
P. Asks for Definitions	14D																
P. Asks for Facts	14F								.1								
P. Asks for Explanations	14X									.3							
P. Asks for Assistance	14A			.4													
P. Gives Information	15+			.1								.1					
P. Defines	15D		.1	.1									.5				
P. States Facts	15F		.1	.2										1.0			
P. Explains	15X			.1											.7		
P. Gives Routine Information	15R		.1	.2													
Silence	16		.1	.4									.1	.1	.1		.9
Total in Each Category		.2	1.3	13.6	3.7	0.6	0	0	.4	1.0	.4	.7	2.8	4.8	2.6	.4	2.9

FIGURE 6 (CONTINUED)

duration can be inferred by comparing the frequencies in the various steady-state 8-8 cells with the frequencies in the various transitional 6-8 cells. The frequency, 0.7 percent, in the 8D-8D steady-state cell, i.e., sustained asking for definition, was more than twice as high as the frequency, 0.3 percent, in the transitional 6D-8D cell. Similarly, the frequency, 1.0 percent, in the 8X-8X steady-state cell, i.e., sustained asking for explanation, was twice as high as that in a transitional 6X-8X cell. By contrast, the frequency, 0.7 percent, in the 8F-8F steady-state cell, i.e., sustained fact seeking, was <u>lower</u> than the frequency, one percent, in the transitional 6F-8F cell. The above figures indicate that the "average" teacher's questions were usually longer than five seconds when asking pupils to define or explain and were of shorter duration, five seconds or less, when asking the pupil to give facts or descriptions.

Thus, as mentioned in the theoretical framework, one can see how the teacher directs and structures the discourse within well prescribed channels. How (well?) the pupil responds and stays within the communication channel -- or to use the felicitous phrase by Bellack and Davitz (1963), "plays the classroom game" -- can be seen by simultaneously studying the various 8-15 and 15-15 cells.

The relative frequencies of the three most common quasi-logical operations used by the "average" teacher are indicated in Figure 6 as column totals for categories 8D (3.1 percent), 8F (4.1 percent) and 8X (3.0 percent). Similarly the corresponding frequencies of pupil responses are indicated as column totals for categories 15D (2.8 percent), 15F (4.8 percent) and 15X (2.6 percent). Clearly factual questions were most frequently asked and factual responses were most frequently given. Moreover, most of the factual responses were of short

duration, 2.7 percent in 8F-15F cell and relatively few factual responses were longer than five seconds, 1.0 percent in the 15F-15F cell. The relative frequencies of the "average" pupil's explanations and definitions show a similar correspondence to the frequencies of the teacher's questions or solicitations for explanation and definitions. But to carry the analysis a step further, if we compare the length or duration of the various kinds of pupil responses, we can make a rather rough approximation that the "average" pupil's definitions, factual answers, and explanations were more frequently short responses lasting five seconds or less rather than longer responses. The frequencies of "short" to "long" responses were roughly four times as high for definitions, three times as high for factual responses, and twice as high for explanations as indicated by comparing the scores in the various 8-15 cells with those in the various 15-15 cells. One may reasonably expect just the reverse, namely, the giving of definitions and explanations by pupils would entail responses of relatively longer duration more often than not. A clue to the solution lies in the duration of the teacher's questions. The reader may recall that teacher questions tend to be of longer duration when seeking definitions and explanations and short when seeking facts. In other words, the teacher's questions were so highly structured that the student needed to give only a word or two or at most a short sentence. To use an analogy to written objective questions such as true-false, multiple-choice, and fill in the blank, the pupil had to verbally "fill in the blank." Several examples of the various kinds of teacher questions are provided in the section on definitions of the categories. For instance, questions related to definitions typically called for one word responses, as illustrated by the question: The blood vessels that carry blood away from the heart are called what, John?

The next step in the pattern, the evaluation of the pupil's substantive responses, can be seen in various 15-2 and 15-3 cells in Figure 6. By far, the preponderant evaluative reaction was the acceptance of the pupil's substantive response. Moreover, the frequencies of acceptance were roughly proportional to the frequencies of response. The relatively low figures in the various 15-3 cells, i.e., correction of pupil's substantive response, offer additional support in concluding that the pupil's response had been satisfactory to the teacher or that the pupil had "given" what the teacher "asked" for. Once again, to continue the analogy: "The pupil has followed the rules of the classroom game " (Bellack and Davitz 1963).

The above quantitative description may be summarized qualitatively. The major part of the biology classroom discourse revolves about the communication of facts, concepts and generalizations of biology. Three basic quasi-logical operations were most frequently used: defining, fact stating and explaining. These operations were predominantly carried out by the teacher in the form of extended information-giving. Occasionally the teacher used a "question and answer approach" to convey definitions, facts and explanations. Certain re ies could be discerned when the "average" teacher asked for def , facts and explanations and the pupil gave the corresponding responses. The teacher was likely to ask relatively long, structured questions when he solicited definitions and explanations so that the pupil merely supplied the "missing word(s)" in a sort of verbal game of filling in the blanks. The pupil's response was then usually accepted, and the teacher resumed lecturin(this is admittedly an over simplification of an extremely complex process of teacher-pupil interaction, but serves the purpose of delineating the phenomenon. There are probably a very large number of variations that

contribute to each teacher's unique style. In the following paragraphs, we return to the 16x16 matrix and continue a brief discussion of some of the variations of the basic pattern and some of the other aspects of classroom behavior.

The above pattern or descriptive model can be represented symbolically as 6→8→15→2 with the numbers representing category designations only and <u>not</u> the frequency of occurrence. Variations in the above pattern were found whenever the teacher or pupil used a different behavior at any place in the above sequence. What are the possibilities open to the teacher when some other category of behavior is substituted for category two, (teacher accepts response) in the sequence -- symbolically represented as 6→8→15↛2. As can be seen in row 15 of Figure 7, a number of possible courses of action were followed, out of which four sequences shown in Figure 7 occurred most frequently. Sequence A -- the teacher followed the pupil's response by more "lecturing"; this sequence could be described symbolically as 6→8→15→6. Sequence B -- the teacher followed the pupil's response by asking another question, 6→8→15→8. Sequence C -- the teacher corrected, qualified or modified the pupil's response, 6→8→15→3. Sequence D -- the teacher decided to provide some orientation or to give some directions after the pupil's response, 6→8→15→11.

Further variations can be found by positing various combinations. In the above cases the variations were introduced by the teacher's behavior following the pupil response, but a consideration of the basic pattern 6→8→15→2 indicates that other possibilities exist for changing the sequence immediately after the teacher asks a question, i.e., 6→8↛15. The possibilities are seen in the 8-14 and 8-16 cells, i.e., the pupil(s) may ask a question or remain silent. Symbolically, these

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1											Patterns						
T. Accepts P's Response	2								A =	6-6 →		6-8 →		8-15 →		15-6		
T. Corrects P's Response	3								B =	6-6 →		6-8 →		8-15 →		15-8		
T. Reprimands Pupil(s)	4								C =	6-6 →		6-8 →		8-15 →		15-3		
T. Demonstrates	5								D =	6-6 →		6-8 →		8-15 →		15-11		
T. Gives Substantive Info.	6						33* →		3.7									
T. Gives Lab. Directions	7																	
T. Seeks Substantive Info.	8					Start Here			2.5	—	—	—	—	—	—	6.4		
T. Looks at P's Work	9																	
T. Asks Procedural Ques.	10																	
T. Gives Procedural Direc.	11																	
T. Attends to Routines	12																	
T. Supervises	13					C			A		B		D					
P. Seeks Information	14																	
P. Gives Information	15				.9		1.2		1.1			.7				2.4		
Silence	16																	
Total in Each Category																		

FIGURE 7 VARIATIONS OF THE MOST COMMON PATTERN OF BEHAVIOR IN BIOLOGY LECTURE CLASSES. Figures in cells are percentages taken from Figure 4. The most common pattern 6-6 --> 6-8 --> 8-15 --> 15-2 was shown in Figure 5. The above variations were brought about by the action taken by the teacher after the pupil "answered" the teacher's (prior) question. See Text.

patterns can be shown as 6→8→14 and 6→8→16.

The identifying feature of all the above variations is that the teacher initiates one of the cycles by asking a question. Hence, if the pattern is "broken" thus $6 \overset{\nearrow}{\searrow} 8$, the basic pattern no longer prevails. As can be seen from row six in the 16x16 matrix (Figure 4), the teacher's information-giving was followed most frequently by category 11, teacher gives orientation, directions, explicates transitions, 1.9 percent in 6-11 cell, and by category 14, pupil questions, 1.1 percent in 6-14 cell, and less frequently by other categories, such as category one, teacher praises, accepts feelings, etc. These sequences, (6→11, 6→14, 6→1) were followed by more lecturing (6→11→6, 6→14→6, 6→1→6) or by more questions from the teacher (6→11→8, 6→14→8, 6→1→8).

The sequences 6→11 and 6→1 are of particular interest. It seems reasonable to speculate that while category 11 is in the procedural dimension and category one is in the affective dimension, these two sequences may be extremely important indicators of a teacher's sensitivity to pupil reactions. By providing orientation, by explicating subtle or difficult transitions from one aspect of a topic to another when the teacher senses confusion, by offering praise and encouragement when the teacher senses frustration, by constructively accepting feelings of annoyance, or stimulating excitement and interest, the teacher can probably exert considerable influence on the cognitive and affective climate of the classroom.

Two other cells in the 16x16 lecture matrix (Figure 4) have relatively high frequencies, namely, the 11-11 cell (6.8 percent) and 12-12 cell (3.3 percent). These cells indicate that the teacher was engaged in the routine business of the classroom, such as giving

assignments, giving directions, taking attendance, collecting papers, distributing papers, etc. These routine duties were characteristically performed at the beginning or the end of the class period and less frequently in the "middle" of the class period.

In the above paragraphs, the major patterns and variations of teacher-pupil interaction in high school biology lecture classes have been delineated by analyzing the grand matrices. At the risk of belaboring the point, the writer wishes to emphasize that the patterns discussed above are not meant to be prescriptive but merely descriptive. The task that lies ahead is one of determining the relationships between various teacher behavior patterns and pupil behavior patterns. This is a research area probably most conveniently carried out with the help of student teachers. Student teachers, with the help of their college supervisors or their sponsor teachers, could hypothesize the effects of certain pattern(s) of teacher behavior on pupil behavior and/or pupil achievement. The student teacher could try to behave according to various hypothesized pattern(s) and then measure the effects on pupil behavior and/or achievement by using interaction analysis or some other instrument. In this way student teachers may "discover" certain principles of teaching. These "discovered" principles would probably be much more meaningful than if the student teachers read about them. Hopefully, such experiences during the student teaching or internship period would develop more "teacher-researchers" who not only teach science but also scientifically study their own teaching.

Analysis of Laboratory Matrices

Before proceeding to the analysis of the laboratory matrices, the reader is reminded that pupils' non-verbal behavior, which constitutes the major portion of the pupils' laboratory work, is not categorized

in the present system. Further, while the teacher was interacting with one pupil or a group of pupils at a laboratory station, the other pupils were usually engaged in laboratory activities.

The 16x16 laboratory matrix (Figure 8) differs from the 16x16 lecture matrix (Figure 4) in two major respects. First, a far greater number of the transitional cells are "filled" in the laboratory matrix. Secondly, no single cell in the laboratory matrix has a disproportionately large value comparable to the 33 percent in the 6-6 cell of the lecture matrix. Indeed, at first glance, it is difficult to see any noticeable sequence of behaviors that could be interpreted as forming a pattern. However, upon closer examination, a certain regularity appears in the steady-state cells, occupying the diagonal from cell 1-1 to cell 16-16. This feature is highlighted in Figure 9. The entries in 7 out of the 16 steady-state cells, namely 5-5, 6-6, 7-7, 9-9, 11-11, 12-12, and 13-13 comprised more than 50 percent of the total entries. These steady-state cells indicate relatively persistent and stable behaviors which constitute the "base of operations" from which the more (temporally) transitional behaviors are initiated by the teacher or more commonly by the pupil(s). The comparable "base of operations" in the lecture classes was the 6-6 cell, prolonged lecturing, followed most often by teacher initiated questions.

Presuming on the reader's greater familiarity with matrix analysis, the writer will describe the interaction patterns briefly. From Figures 8 and 9 it can be seen that the "average" teacher's behavior in the laboratory was characterized by several varied, short, quick interactions, shifting from one category of behavior to another. The "average" biology teacher usually started the class by one or more of the following behaviors: a short lecture, 6-6 cell; laboratory directions, 7-7 cell; demonstration

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1	.2					.1	.1		.1		.1	.1	.1				
T. Accepts P's Response	2		.1				.6	.1	.4	.1		.2	.1	.1				
T. Corrects P's Response	3			.1			.2		.1									
T. Reprimands Pupil(s)	4				.4		.1					.1	.1	.1				
T. Demonstrates	5					2.0	.3	.6				.1			.1	.1		
T. Gives Substantive Info.	6	.1				.3	8.6	.6	.8	.2	.1	.6	.2	.3	1.0	.4		
T. Gives Lab. Directions	7					.6	.6	6.9	.2	.6	.2	.6	.3	.7	.9	.2		
T. Seeks Substantive Info.	8						.2	.1	.8			.1			.1	2.7	.2	
T. Looks at P's Work	9	.1				.1	.2	.7	.3	5.6	.2	.2	.1	.5	.4	.1		
T. Asks Procedural Ques.	10							.1		.1	.2	.2	.2	.1	.1	1.2		
T. Gives Procedural Direc.	11	.1			.1	.1	.5	.5	.2	.3	.3	6.8	1.1	.6	1.0	.2	.2	
T. Attends to Routines	12						.1	.1	.1	.1	.3	.8	2.7	.3	.8	.1		
T. Supervises	13				.1			.1	.1	.8	.2	.3	.3	6.7	.8	.1		
P. Seeks Information	14		.2	.1	.1	.1	1.3	1.3	.2	.5	.3	1.5	.1		.6	.1		
P. Gives Information	15	.2	1.3	.3	.1	.1	.6	.4	.6	.3	.3	.6	.2	.2	.2	1.0		
Silence	16						.1		.1			.2			.1	.1	.4	
Total in Each Category		0.7	1.6	0.5	0.8	3.3	13.5	11.6	3.9	8.7	2.1	12.4	15.5	10.0	6.1	6.3	0.8	97.8

FIGURE 8 16x16 INTERACTION MATRIX BASED ON 48 LABORATORY PERIODS OF 10 TEACHERS. Figures in cells = % of 28,046 observations, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first, column next, e.g., cell 15=3 is read as P Gives Information and T Corrects P's Response. (Column totals do not add up to 100% due to rounding).

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1																	
T. Accepts P's Response	2																	
T. Corrects P's Response	3																	
T. Reprimands Pupil(s)	4																	
T. Demonstrates	5					2.0												
T. Gives Substantive Info.	6						8.6							→	1.0		→	
T. Gives Lab. Directions	7						↑	6.9						→	0.9		→	
T. Seeks Substantive Info.	8						↑	↑										
T. Looks at P's Work	9									5.6								
T. Asks Procedural Ques.	10																	
T. Gives Procedural Direc.	11											6.8	→		1.0		→	
T. Attends to Routines	12												12.7	→	.8		→	
T. Supervises	13													6.7	→ .8		→	
P. Seeks Information	14						1.3	1.3				1.5						
P. Gives Information	15						↑	↑				↑						
Silence	16																	
Total in Each Category																		

FIGURE 9 THE MOST COMMON PATTERNS OF BEHAVIOR IN BIOLOGY LABORATORY CLASSES. Figures in cells are percentages taken from Figure 8. Start each sequence with one of the steady-state cells (in the diagonal) and follow arrows, e.g., 6-6 → 6-14 → 14-6 (or 14-7, or 14-11) → 6-6... See Text.

of laboratory techniques, 5-5 cell; and procedural or routine directions, 11-11 cell. This information-giving phase usually lasted a few minutes and was usually terminated by a directive from the teacher to the pupils, such as "O.K., you can start now." Almost immediately (note the almost complete absence of entries in category 16, silence) pupils initiated a series of similar cycles of behavior by asking for substantive information, for more laboratory directions, for procedural directions, for materials and assistance. The teacher responded by repeating or by giving further substantive information, laboratory directions, procedural directions, and by supplying materials. These cycles (shown in Figure 9) can be described in symbolic notation as follows: 6 → 14 → 6, 7 → 14 → 7, 11 → 14 → 11.

After the initial flurry of activity, the average teacher started supervising the laboratory work. Most often this was done by walking around the laboratory and less frequently by sitting or standing at some location and watching the pupils. At times the teacher stopped at a laboratory desk to watch or examine a pupil's work or to ask questions. Occasionally, the teacher saw something a pupil had done or was asked a question by a pupil and the teacher "called the class to attention" and gave further substantive information, directions, demonstrations, etc. However, from the great number of entries in the transitional cells and the relative frequencies in the cells in row 14, i.e., teacher behavior following pupil questions, it can be inferred that a considerable amount of teacher behavior was responsive to pupil requests rather than initiatory as in lecture classes. Again to use Bellack's analogy, "the rules of the game were reversed." What specific kinds of questions did pupils ask in laboratories? What kinds of teacher behaviors preceded (triggered?) specific kinds of pupil

questions? The answers to these questions can be found by examining the 31x31 laboratory matrix (Figure 10).

In Figure 10 the total scores in columns 14+, 14D, 14F, 14X and 14A indicate the relative frequencies of the various kinds of pupil questions. The "average" pupil asked for assistance, materials, directions etc. (4.4 percent in column 14A) four times as often as all other types of questions combined. The four kinds of teacher behaviors that most frequently preceded the pupils' requests for assistance were:

1. Laboratory directions, 0.8 percent in the 7+-14A cell.
2. Procedural directions, 0.8 percent in the 11-14A cell.
3. Teacher attending to routines, 0.6 percent in the 12-14A cell.
4. Teacher engaged in supervision, 0.7 percent in the 13-14A cell.

The reader may recall that these four teacher behaviors preceding pupil questions were depicted earlier in Figure 9 as constituting some of the most common patterns in labs. The additional or more specific information available from an analysis of the 31x31 matrix can be stated thus: pupils followed the above teacher behaviors almost entirely with solicitations for assistance with materials, directions, etc. In other words, most of the pupils' questions in labs seem to be concerned with "how," "where" and "what" rather than "why".

What is the significance of the preponderance of such "procedural" questions as compared to "substantive" questions in laboratory classes? Are the laboratory directions insufficient? Is the "average" pupil incapable of following laboratory directions without the teacher's assistance? Why do pupils ask the "why" type of question so infrequently? What specific kinds of questions would predominate in laboratory classes devoted to experimentation as compared to verification and demonstration of subject matter mentioned in textbooks? What kinds of questions do

CATEGORY		1	2	3	4	5	6+	6D	6F	6X	6E	7+	8+	8D	8F	8X
T. Praises	1	.2										.1				
T. Accepts	2		.1					.2	.2			.1		.1	.1	.1
T. Corrects	3			.1					.1							
T. Reprimands	4				.1											
T. Demonstrates	5					2.0			.2	.1		.6				
T. Gives Information	6+						.1									
T. Defines	6D							.9	.1	.3				.1		
T. States Facts	6F					.1		.1	3.0	.3	.1	.3		.1	.2	.1
T. Explains	6X					.1		.1	.1	3.8		.2			.1	.2
T. Gives Evaluations	6E										.1					
T. Gives Lab. Directions	7+	.1				.6			.2	.3		6.9			.2	
T. Seeks Information	8+															
T. Asks for Definitions	8D													.1		
T. Asks for Facts	8F								.1						.3	
T. Asks for Explanations	8X															.2
T. Looks at P's Work	9	.1	.1						.1			.7			.3	
T. Asks Procedural Questions	10															
T. Gives Procedural Directions	11	.1			.1	.1		.1	.3	.1		.5			.1	
T. Attends to Routines	12								.1			.1			.1	
T. Supervises	13				.1							.1			.1	
P. Seeks Information	14+															
P. Asks for Definitions	14D							.1								
P. Asks for Facts	14F								.5							
P. Asks for Explanations	14X									.3						
P. Asks for Assistance	14A		.1						.1	.1		1.4			.1	
P. Gives Information	15+	.1														
P. Defines	15D		.3	.1												
P. States Facts	15F	.1	.5	.1		.1			.2	.1		.3			.3	.1
P. Explains	15X		.4	.1						.1						
P. Gives Routine Information	15R															
Silence	16															
Total in Each Category		.7	1.5	.4	.6	3.0	.1	1.5	5.3	5.3	.2	11.3	0	.4	1.9	.7

FIGURE 10 31x31 INTERACTION MATRIX BASED ON 48 LABORATORY PERIODS OF 10 BIOLOGY TEACHERS. Figures in cells = % of 2%,04% observations, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15F-2 is read as P States Facts and T Accepts.

CATEGORY		9	10	11	12	13	14+	14D	14F	14X	14A	15+	15D	15F	15X	15R	16
T. Praises	1	.1		.1							.2						
T. Accepts	2	.1		.2		.1					.1						
T. Corrects	3																
T. Reprimands	4			.1		.1											
T. Demonstrates	5			.1							.1			.1			
T. Gives Information	6+																
T. Defines	6D			.1													
T. States Facts	6F	.1	.1	.3	.1	.1		.1	.1	.1	.2			.1			
T. Explains	6X	.1	.1	.2	.1	.1			.1	.1	.1			.1			
T. Gives Evaluations	6E																
T. Gives Lab. Directions	7+	.6	.2	.5	.3	.5			.1		.8			.2			
T. Seeks Information	8+													.1			
T. Asks for Definitions	8D												.4				
T. Asks for Facts	8F												.1	1.5			.1
T. Asks for Explanations	8X														.6		
T. Looks at Pts Work	9	5.6	.2	.2	.1	.5					.3			.1			
T. Asks Procedural Questions	10	.1	.2	.2	.1						.1			.1		1.0	
T. Gives Procedural Directions	11	.3	.3	6.8	1.1	.6			.1		.8			.1		.1	.2
T. Attends to Routines	12	.1	.2	.8	12.7	.3			.1		.6						
T. Supervises	13	.8	.2	.3	.3	6.7			.1		.7						
P. Seeks Information	14+																
P. Asks for Definitions	14D							.1									
P. Asks for Facts	14F								.1								
P. Asks for Explanations	14X									.1							
P. Asks for Assistance	14A	.4	.2	1.4	.1						.4						
P. Gives Information	15+			.1									.1				
P. Defines	15D																
P. States Facts	15F	.2		.1	.1						.1			.6			
P. Explains	15X														.2		
P. Gives Routine Information	15R	.1	.2	.3	.2	.1											
Silence	16			.2										.1			.4
Total in Each Category		8.6	1.9	12.0	15.2	9.1	0	.2	.6	.3	4.4	0	.6	3.1	.8	1.1	.7

FIGURE 10 (CONTINUED)

pupils ask each other as they work in groups of two to four in the laboratory class? What pupils say and do in the laboratory classes is an important and unexplored area for future research.

The writer will now shift focus and briefly consider the question: How does the "average" teacher use the quasi-logical operations of information giving and seeking in laboratory classes? An examination of the areas of the matrix (Figure 10) made up of the groups of cells representing the various sub-categories of categories six and eight reveals the distribution of the various quasi-logical operations used by the teacher. Sustained explanations, 3.8 percent in the 6X-6X cell, and sustained fact stating, 3.0 percent in the 6F-6F cell, constituted the two major quasi-logical operations used in substantive information-giving. By contrast, sustained definition-giving, 0.9 percent in the 6D-6D cell, and sustained evaluation, 0.1 percent in the 6E-6E cell, were used relatively infrequently. Furthermore, the total amounts of fact stating and explaining were equal, 5.3 percent in columns 6F and 6X. The teacher's questions or solicitations for definitions and explanations were quite infrequent, a total of about 0.5 percent and 0.7 percent in columns 8D and 8X respectively. The dominant type of teacher question was one calling for factual information from the pupils, about two percent in column 8F. It should also be noted that this two percent is fairly well distributed among 11 cells in column 8F of the matrix. From the above figures, it can be inferred that the teacher asked predominantly "factual" questions following a variety of behaviors. These questions predominantly consisted of asking pupils to indicate what results they had obtained and called for relatively little explanation and interpretation of the data.

The above description of various teacher and pupil behaviors in biology classes is admittedly a simplification of a complex, rapidly

shifting behavioral setting. The emphasis has been in highlighting those patterns that are more characteristic of laboratory classes than lecture classes. However, a number of the sequences and patterns found in lecture classes are present in laboratory classes, but are not as prominent.

From the description of teacher-pupil interaction presented above, and from the data in Table 7, one may infer that the verbal discourse contains very few, less than 0.1 percent, explicit references to the processes of science. It is probable that various processes of science are mentioned in textbooks and laboratory manuals used in high school biology, especially in the newer or "modern" programs. A system of content analysis would need to be developed to ascertain the kinds of statements and their relative frequencies. A content analysis system would be a valuable addition to the interaction analysis system in providing a fuller description of what pupils read, as well as say and do in the study of biology, or the other sciences for that matter.

However, the question still intrigues the writer as to why there are so many explicit references to the products of science and so few to the processes of science. Perhaps part of the answer is that teachers teach in the ways that they have been taught. A similar conclusion has been reached by many "critics" of science laboratory classes, or "lecture classes" for that matter. One may find such criticism in a number of journal articles which describe the laboratory as a place where students merely verify what is stated in the textbook. Rather than engage in polemics, the writer advocates an intensive program of research on teacher and pupil behavior in science laboratories. The electronic equipment and techniques developed and used in this study and the application of interaction analysis offer a promising, albeit far from perfect, approach

to what teachers and to a lesser extent pupils actually say and do in laboratory classes.

While there is much talk about the laboratory as the sine qua non of teaching science as inquiry, the writer is of the conviction that until the specific behavioral acts that constitute "teaching for inquiry" can be unambiguously described, teachers will find little practical guidance in the expression of admirable sentiments. Probably a prerequisite to a "no holds barred" study of "teaching for inquiry" is the admission that very little indeed is known about the subject that can be taught to and practiced by science teachers.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

Reviewers of the literature related to studies of teacher effectiveness have been in agreement about the inconclusiveness of research attempting to relate teacher characteristics to teacher effectiveness. Within the last decade, the emphasis has been on a new, or at least different, research strategy. The key feature, or "tactic" in this strategy consists of first hand, systematic, objective observation and quantitative analysis of teacher-pupil interaction in classrooms. Ideally, this descriptive phase should be guided by available theory and the empirical findings in turn should enrich the theoretical concepts so that significant well-articulated correlational and predictive studies can be undertaken.

Researchers, using different theoretical perspectives, have provided a handful of category systems for systematic observation and analysis of classroom behavior. Some of these category systems are fairly useable over a wide range of grade levels and subject-matter disciplines. Conspicuously absent is a category system specifically developed for systematic observation of science classes, especially laboratory classes, the sine qua non of teaching science as process(es) of inquiry.

Concisely stated, the primary purpose of this study was to develop a category system for first hand systematic observation, description and quantitative analysis of teacher-pupil interaction in high school biology

lecture-discussion-recitation classes and laboratory classes. Owing to the magnitude of the undertaking and on the basis of theoretical considerations, the major emphasis was placed on the classification of the cognitive or "intellectual" behaviors of teachers. A second major objective was to use the "new" category system for classroom observation, and from the data so obtained, to construct tentative descriptive models of biology teaching. It was anticipated that the results of this exploratory study would lead to further clarification of theoretical notions and to the formulation of more specific questions and hypotheses for future research.

In fulfillment of the two major objectives, the research was divided into two phases or stages. In the first or category development phase of the study, eight high school biology teachers in eight secondary schools in central New York State were selected. The criteria for selection included some of the major factors most likely to influence classroom interaction, such as: type of biology course taught, namely, New York State Regents Biology or the "new" or BSCS Biology, size and location of school, years of teaching experience. In the category development phase, each teacher was observed once per month for four successive months commencing October, 1964. Greater differences in classroom behavior were most likely to be sampled by visits at monthly intervals rather than on consecutive days or weeks. During each visit, the classroom discourse for the entire duration of one lecture-discussion-recitation and one laboratory class was recorded on magnetic tape. In addition, the observer took notes on pedagogically relevant non-verbal behavior to supplement tapescripts prepared from the tapes. Following the classroom visits, the notes were carefully studied, and the tapes were replayed. The empirical data thus obtained provided the grist for the

theoretical mill, and the category system reported in this study was produced by a complex interplay of theory and observation.

The major concepts constituting the theoretical frame of reference were derived from a consideration of teaching as a special case of social interaction carried on via verbal and non-verbal communication between the teacher and pupil(s). Furthermore, by virtue of his position as a leader, the teacher was viewed as exercising, or capable of exercising, considerable control over the form and content of classroom communication. The major purpose or business of the classroom was posited as the attainment of educational objectives in the affective, cognitive, and psychomotor domains, but, predominantly in the cognitive domain. The cognitive domain or dimension was divided into two subdimensions, namely, Substantive Information-Giving and Substantive Information-Seeking. The substantive information in high school biology was said to be composed of both the product--the facts, concepts, principles, etc.--and the processes of science. Drawing upon the research by Smith et. al. (1962 b.) and Bellack and Davitz (1963), substantive information in biology classes was presumed to be communicated or exchanged verbally by logical, or more accurately, quasi-logical processes of defining, fact stating and describing, explaining, and evaluating subject matter. The major focus was directed at the teacher's behavior, which was considered to be largely initiatory, while the pupil's behavior was viewed largely as reflexive. Only pupil behavior that was categorizable within the Pupil-Talk Dimension was included. The conception of the teacher as a leader who gave evaluative and directive "information" as ancillary to and facilitative of cognitive outcomes led to the formulation of Evaluative and Procedural Dimensions of teacher behavior. The theoretical possibility supported by empirical verification

of short breaks or pauses in the communication process led to the formulation of Silence as a "dimension" of classroom life.

The category system developed in this study contained the above-mentioned five "dimensions," which in turn were divided into 16 major categories, 28 sub-categories and a "residual" category for behavior not categorizable in the system. The Evaluative Dimension is composed of four major categories: T (Teacher) Praises P (Pupil), T Accepts P's Substantive Response, T Corrects P's Substantive Response, and T Reprimands P for Misbehavior. The Cognitive Dimension subsumes five major categories: T Gives Demonstration, T Gives Substantive Information, T Gives Laboratory Directions, T Asks for Substantive Information and T Looks at P's Laboratory work or seat work. The Substantive Information-Giving and Information-Seeking Categories are sub-divided according to the quasi-logical operations of defining, fact stating, explaining, and evaluating the product or subject matter of biology. Another sub-category is provided for classification of explicit references to the Process or Nature of Science. The reader may consult the text (Chapter III) for the description and definition of each category. The Procedural Dimension has four major categories: T Asks Procedural Routine Questions; T Gives Procedural Directives, Gives Orientation, Explicates Transitions; T Attends to Routines; T Supervises P's work. The Pupil-Talk Dimension has two major categories: P Asks for Information and Assistance and P Gives Response. These two categories are sub-divided according to "logical" and "procedural" criteria. The "Silence Dimension" consists of only one category, namely, Silence. The residual category is simply called "Not Categorizable in Above System."

The category system, briefly described above, was then used for the systematic observation of fourteen biology teachers in order to

obtain descriptive data to fulfill the second major objective. The teachers were selected according to the criteria mentioned before. However, owing to unforseen schedule changes and circumstances, data was obtained for four lectures and four laboratory periods for each of ten teachers. In this, the second phase of the study, each teacher was visited once each week for at least four successive weeks. During each visit the classroom discourse for the entire duration of one lecture-discusiion-recitation class and one laboratory class was recorded on magnetic tape and the teacher-pupil interaction was coded "on the spot" once every five seconds or so. A small wireless transmitter was "worn" by teachers during laboratory classes to enable the observer to hear and record whispered and low-decibel-level conversation between teacher and pupil at individual laboratory tables. The "wireless broadcast" was received via a compact FM radio, played into a tape recorder and simultaneously monitored with the aid of earphones worn by the observer.

The observational record consisted of a series of category numbers or observations written in horizontal rows so as to preserve the original sequence of behavior. These numbers or observations were processed via a 1604 Control Data Corporation computer to yield the relative frequency of occurrence of each category. The data were plotted into 16x16 and 44x44 matrices. The frequency distributions and matrices were analyzed to provide a quantitative description of classroom behavior in lecture and laboratory classes of the "average" biology teacher.

The predominant feature of biology classroom life was found to be the amount of teacher talk. About 75 percent and 50 percent of the total observations in lecture and laboratory classes were attributed to teacher-talk. The non-verbal behavior of teachers accounted for about 10 percent of the total time in lectures but nearly 40 percent in laboratory

classes. Pupil talk accounted for about 15 percent in both lectures and labs.

A comparison of the frequencies of occurrence of teacher behaviors in each of the three dimensions showed that the "average" teacher devoted a considerable amount of time to the Cognitive Dimension, 55 percent in lecture classes and 42 percent in labs. The Procedural Dimension was found to account for an average of 18 percent of total time in lectures and 40 percent in labs. By contrast, an average of only 10 percent of total time in lectures and 4 percent of the time in labs was devoted to the Evaluative Dimension.

Within the Cognitive Dimension it was found that the teacher's substantive information-giving behavior was the predominant mode of communication. The most common pattern in lecture classes was found to be: teacher lecturing for a period of time interspersed with a sequence of questions asked by the teacher, pupil responses, and teacher's acceptance of pupil's responses. Many variations of this basic pattern were also found. In laboratory classes two more or less distinct phases were found. In the first phase, at the beginning of the period the teacher gave substantive information, laboratory directions and less frequently demonstrations of techniques. In the second phase, the behavior pattern changed markedly from teacher initiation to pupil initiation. As the teacher walked around the laboratory or attended to routine tasks, he was constantly bombarded by pupil solicitations for laboratory supplies, further directions and information, and assistance with the performances of laboratory activities.

The substantive information-giving and information-seeking behavior, which formed the core of classroom communication, was subjected to a deeper level of analysis. Four quasi-logical operations of teaching

were used in the following order, starting with the highest frequency of occurrence, namely, fact stating, explaining, defining, and evaluating subject matter. Approximately half of the time these operations were used in relatively discrete "packets" of facts, explanations, etc., and during the other half of the time there was a complex shifting and meshing of the various quasi-logical processes in rapidly alternating sequences of information-giving and information-seeking.

Teacher demonstrations and explicit statements and questions about the nature and processes of science occurred so infrequently as to be conspicuous by their absence. The wide gulf between recommended practices and classroom practices implied by these findings raise many questions that require serious consideration and research. Several questions requiring research "answers" have been raised throughout the discussion of results and will not be repeated here.

Recommendations for Future Research

The major recommendations for future research growing out of the present study are stated below. (The order of presentation should not be construed as indicative of relative importance.)

1. The range of applicability of the present category system should be extended to the other science subjects: General Science, Earth Science, Physics, and Chemistry, taught at various grade levels. On the basis of preliminary investigation such an extension seems quite feasible. Certain refinements and modifications could be incorporated as needed.

2. An area of research, related to the above, is the development of supplementary systems of analysis that could be used with the present system to provide a fuller description and understanding of science-teaching and learning. Especially germane would be a system for

categorizing more fully the behavior of pupils in laboratory classes and a content analysis system for analysing textbooks and laboratory manuals.

3. Considerable research activity should be directed toward the development of other category systems based on different theoretical or conceptual frameworks. The complexity of the phenomena under study and the paucity of theory and empirical data preclude consideration of the present system or any other system as definitive. Such a period of classifying and cross classifying from one category system to another is essential in the development of a comprehensive taxonomy of classroom behavior.

4. The trend towards use of interaction analysis as a research instrument as well as a pedagogical device is becoming increasingly popular among educators. While the writer is enthusiastic about the potential, studies of the potentialities of an instrument should be counter-balanced by systematic studies of the limitations of an instrument. While such painstaking methodological studies may have little appeal, their importance should not be underestimated. Unwittingly, gross distortions may be introduced into our "picture" or description of classroom behavior, and without a fuller understanding of the instrument, we will be unaware of the possible sources of distortion, to say nothing of correcting the aberrations. Parenthetically, it may be noted that such methodological studies need not be devoid of a theoretical basis.

5. An important area of research is the determination of functional relationships among four major classes of variables, namely; the antecedents of teacher's classroom behavior, teacher's classroom behavior, pupils' classroom behavior and pupil learnings. While a

number of measures of these variables have been used, these measures cannot provide specific answers to the kinds of specific questions that can be asked on the basis of the information available from interaction analysis. Thus, development of specific tests of pupil learnings will need to proceed apace with the kinds of correlational research suggested above.

6. The use of interaction analysis as a means of providing student teachers with objective feedback is finding increasing application. A prediction that it will become the method of supervising or guiding student teachers would be premature. Perhaps the writer is overly pessimistic; but, there seems to be a danger of gradually shifting from descriptive statements, direct-indirect, student centered-learner centered, to prescriptive formulations. In order to avoid repeating past failures of comparative research, wherein Method A was compared with Method B, guarded optimism is in order. With this cautionary note, the writer feels free to recommend an exciting area of research in the pre-service and in-service training of teachers. The use of interaction analysis as a device to study at first hand the effects of various patterns of teacher behavior on pupil behavior holds promise as a tremendously viable area of research. A few research problems are given below to suggest the potentialities.

a. The most common pattern of classroom behavior was found to be a sequence consisting of the following: Teacher lectures, teacher asks question, pupil responds, teacher accepts response. In what specific ways would the classroom behavior and/or achievement of pupils be affected if the teacher deliberately changed this pattern at appropriate times? For example, the

teacher could change his role as sole evaluator of pupil responses by asking other pupils to evaluate their peers' response.

b. Assuming that the teacher wishes to develop creativity, critical thinking, scientific attitudes and so on in his students, what kinds of questions would he ask and what kinds of pupil responses would he encourage? In this study it was found that the teacher's questions were usually so highly structured that pupils often just had to verbally "fill in the blanks." The writer is of the opinion that questions such as the above require little critical thinking and even less creative thinking. By drawing upon the literature in educational psychology, the teacher could try out various questioning techniques and analyze the classroom discourse to see what effects are produced.

c. In a number of "science-methods" courses, the students are required to observe a number of lecture and laboratory classes predominantly for the purpose of "seeing the real thing." The observation may be highly structured or extremely unstructured. Opinion seems to be divided as to the value of this procedure. Would the above students acquire a deeper understanding of teaching if they used one or more category systems as observational techniques?

d. Frequently, the "principle" is stated that the "way" in which a teacher conducts his class depends on a

number of factors, such as ability level of the class, the particular "unit" being taught, and whether it is the beginning, the middle or the end of a unit and so on. What specifically are some of the "ways" or teacher behaviors that characterize the teaching in each of the above situations?

REFERENCES

1. Amido.., Edmund J. and Flanders, N.A. The Role of the Teacher in in the Classroom: A Manual for Understanding and Improving Teachers' Classroom Behavior. Amidon and Associates, Inc.; Minnesota 1963. Mimeo.

2. Amidon, Edmund J. Personal Communication: Two day workshop on the Flanders' system of interaction analysis at Cornell University; Spring 1964.

3. Amidon, Edmund J. and Hunter, E. The Amidon System of Interaction Analysis. 17 pp. Unpublished Mimeo.

4. Amidon, Edmund J. and Simon A. Teacher-Pupil Interaction. Review of Educational Research. 35(2):130-139. 1965.

5. Anderson, Harold H. The Measurement of Domination and of Socially Integrative Behavior in Teachers' Contacts with Children. Child Development 10:73-89; 1939.

6. Anderson, Kenneth E. Science Instruction and the Laboratory. School Science and Mathematics 49 (5): 367-370. 1949.

7. Aschner, Mary Jane McCue. The Analysis of Verbal Interaction in the Classroom, p. 53-78 in Theory and Research in Teaching. A. A. Bellack (Ed.) Bureau of Publications, Teachers College, Columbia University; New York 1963.

8. Bales, Robert F. Interaction Process Analysis. Addison - Wesley, Cambridge, Massachusetts; 1950.

9. Bellack, Arno A., and Davitz, J. L. The Language of the Classroom. Institute of Psychological Research. Teachers College, Columbia University; New York 1963, Mimeo. (Report CRP No. 1497)

10. Berelson, Bernard. Content Analysis in Communication Research. The Free Press; Glencoe, Illinois 1952.

11. Bloom, Benjamin S. (Ed.) Taxonomy of Educational Objectives: Cognitive Domain. Longmans Green and Company; New York 1954.

12. Bloom, Benjamin S. (Ed) Taxonomy of Educational Objectives. Affective Domain. David McKay Co., N. Y. 1964.

13. Cunningham, Harry A. Lecture Demonstration Versus Individual Laboratory Method in Science Teaching - A Summary. Science Education 30 (2): 70-82; 1946.

14. Flanders, Ned A. Using Interaction Analysis in the Inservice Training of Teachers. Journal of Experimental Education 30 (4): 313-316; 1962.

15. Flanders, Ned A. Intent, Action and Feedback. A Preparation for Teaching. Journal of Teacher Education 14(2): 251-260. 1963.

16. Flanders, Ned A. Interaction Models of Critical Teaching Behaviors. p. 197-218 in An Analysis and Projection of Research in Teacher Education. Ohio State University, Columbus, Ohio Mimeo (Report CRP. No. F-015) 1964(a).

17. Flanders, Ned A. Interaction Analysis in the Classroom: A Manual for Observers. Revised Edition. School of Education, University of Michigan; Ann Arbor, Michigan, 1964(b).

18. Gage, N. L. (Ed) Handbook of Research on Teaching. Rand McNally & Co. Chicago, Illinois 1963.

19. Gage, N. L. Theories of Teaching, p. 268-285 in Theories of Learning and Instruction, E. R. Hilgard (Ed). NSSE Yearbook; 63 (1); 1955.

20. Gellert, Elizabeth. Systematic Observation: A Method in Child Study. Harvard Educational Review 25 (3): 179-195; 1955.

21. Gerbner, George. A Theory of Communication and its Implications for Teaching . p. 33-49 in The Nature of Teaching. L. M. Berman (Ed.) University of Wisconsin Press; Milwaukee, Wisconsin, 1963.

22. Getzels, Jacob M. & Thelen, H. W. The Classroom Group as a Unique Social System. p. 53-82 in Dynamics of Instructional Groups, N. B. Henry (Ed.) NSSE Yearbook 59 (2) 1960.

23. Guilford, Joy P., and Merrifield, P. R. The Structure of Intellect Model: Its Uses and Implications. The Psychological Laboratory of the University of Southern California; Report No. 24, 1960.

24. Hare, A. Paul. Handbook of Small Group Research. Free Press of Glencoe, New York, 1962.

25. Hawse, Doris H. Ooh! Worms. Science Education 41 (5): 436-439; 1957.

26. Heyns, Roger W., and Lippitt, R. Systematic Observational Techniques p. 370-404 in Handbook of Social Psychology. Vol. 1, G. Lindzey (Ed.), Addison-Wesley; Cambridge, Massachusetts, 1954.

27. Hockett, Charles F. A Course in Modern Linguistics. MacMillan Co., New York, 1958.

28. Hollander, E. P. and Hunt, R. G. (Ed.) Current Perspectives in Social Psychology. Oxford University Press, New York, 1963.

29. Hughes, Marie M. and Associates. Assessment of the Quality of Teaching in Elementary Schools. A Research Report. University of Utah; 1959 Mimeo.

30. Lambert, William W. Personal Communication and Class Notes from Course in Social Psychology at Cornell University, Fall 1964.

31. Levin, Harry A. New Perspectives on Teacher Competence Research. Harvard Educational Review 24: 98-105; 1954.

32. Lewin, Kurt, Lippitt, R. and White, R. K. Patterns of Aggressive Behavior in Experimentally Created "Social Climates". Journal of Social Psychology 10: 271-299; 1939.

33. Mark, Steven J. Experimental Study Involving the Comparison of Two Methods of Performing Experiments in High School Chemistry. Science Education 45 (5): 410-412; 1961.

34. Medley, Donald M., and Mitzell, H. E. Measuring Classroom Behavior by Systematic Observation. p. 247-328 in Handbook of Research on Teaching N. L. Gage (Ed.) Rand McNally and Company; Chicago, Illinois, 1963.

35. Ryans, David G. Characteristics of Teachers. American Council on Education; 1960.

36. Ryans, David G. Possible Directions for Teacher-Behavior Research. Theory Into Practice 2 (2): 105-112; 1963.

37. Schwab, Joseph J. (Supervisor). Biology Teachers' Handbook. John Wiley and Sons: New York, 1963.

38. Scott, W. A. Reliability of Content Analysis: The Case of Nominal Scale Coding. Public Opinion Quarterly 19:321-325; 1955.

39. Smith, B. Othaniel. A Concept of Teaching. Teachers College Record 61(5): 229-241; 1960.

40. Smith, B. Othaniel. Conceptual Frameworks for Analysis of Classroom Social Interaction. Journal of Experimental Education 30(4) 325-326; 1962(a)

41. Smith, B. Othaniel, Meux, M. O. and Associates. A Study of the Logic of Teaching. University of Illinois; Urbana, Illinois, Mimeo (CRP. No. 258)1962(b).

42. Smith, B. Othaniel. A Conceptual Analysis of Instructional Behavior. Journal of Teacher Education 14 (3): 294-298; 1963.

43. Snider, Ray M. Personal Communication 1965.

44. Suchman, J. Richard. The Elementaty School Training Program in Scientific Inquiry. University of Illinois; Urbana, Illinois, 1962 Mimeo.

45. Thelen, Herbert A. . Insights for Teaching from a Theory of Interaction, p. 19-31 in The Nature of Teaching, L. M. Berman (Ed.) University of Wisconsin Press; Milwaukee, Wisconsin, 1963.

46. Thomas, Dorothy A., and Associates. Some New Techniques for Studying Social Behavior. Child Development Monograph 1, 1929.

47. Watson, Fletcher G., and Cooley, W. W. "Needed Research in Science Education" p. 297-312 in Rethinking Science Education. N. B. Henry (Ed.) NSSE Yearbook 63 (1): 1960.

48. Watson, Fletcher G. "Research on Teaching Science" p. 1031-1059 in Handbook on Research in Teaching. N. L. Gage (Ed.) Rand McNally and Co.; Chicago, Illinois, 1963.

49. Weckstein, Abraham. Laboratory Work in Elementary General Biology. Science Education 23 (7): 373-379; 1939.

50. Withall, John. The Development of a Technique for the Measurement of Social-Emotional Climate in Classrooms. Journal of Experimental Education 17: 347-361; 1949.

51. Withall, John. The Development of a Climate Index. Journal of Educational Research 45: 93-99; 1951.

52. Withall, John, and Lewis, W. W. Soical Interaction in the Classroom p. 683-714 in Handbook of Research on Teaching. N. L. Gage (Ed.) Rand McNally & Co.; Chicago, Illinois, 1963.

53. Wright, Muriel J., and Proctor, V. H. Systematic Observations of Verbal Interaction as a Method of Comparing Mathematics Lessons. Research Report, Washington University; St. Louis, Missouri, 1961 Mimeo. (Report CRP. No. 816).

APPENDIX

"16x16" INTERACTION MATRICES OF LECTURE AND LABORATORY CLASSES OF TEN BIOLOGY TEACHERS

The discussion of matrices in the text was confined to the grand matrices. These matrices were plotted from all the observational data obtained from 40 lecture periods and 48 laboratory periods of the 10 teachers. The major aim of the discussion was to provide a descriptive model or a composite picture rather than to delineate the numerous individual differences among the teachers. Differences in "teaching styles" or "interaction patterns" can be readily seen in the appended matrices of each teacher. Each matrix was plotted from four lecture classes or four laboratory classes. The reader may refer to Figures 4, 5, 7, 8, and 9 in the text for a comparison between any particular teacher and the "average" teacher.

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1	.6					.5		.5			.3				.2		
T. Accepts P's Response	2	.2	.4				3.2		3.3			.4	.1			.1		
T. Corrects P's Response	3						.4		.2			.1				.1		
T. Reprimands Pupil(s)	4				.1		.2					.1						
T. Demonstrates	5																	
T. Gives Substantive Info.	6	.4	.1		.2		34.5		4.9		.3	2.0			.6	.1	.1	
T. Gives Lab. Directions	7							.1										
T. Seeks Substantive Info.	8						1.2		5.0			.1				9.1	1.5	
T. Looks at P's Work	9																	
T. Asks Procedural Ques.	10						.2				.2	.4			.1	.3		
T. Gives Procedural Direc.	11	.2			.1		1.6		1.4		.3	6.1	.3	.1	.3	.1	.1	
T. Attends to Routines	12								.1			.3	.8					
T. Supervises	13													.8				
P. Seeks Information	14						.6		.1		.1	.2			.4			
P. Gives Information	15	.5	7.2	.8			.5		.9		.2	.2				.3		
Silence	16	.2					.3		.5			.3				.4	.1	
Total in Each Category		2.1	7.7	0.8	0.4	0	43.2	0.1	16.9	0	1.1	10.5	1.2	0.9	1.4	10.7	1.8	99

FIGURE A1 16x16 INTERACTION MATRIX BASED ON 4 LECTURE CLASSES OF BIOLOGY TEACHER #1
Figures in cells = % of 2245 observations, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15-2 is read as P Gives Information and T Accepts P's Response. (Column totals do not add up to 100% due to rounding).

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1						.1									.1		
T. Accepts P's Response	2	.1	.7	.1	.1		4.4		1.1			.2			.2	.1		
T. Corrects P's Response	3						.4		.6						.1	.3		
T. Reprimands Pupil(s)	4						.1											
T. Demonstrates	5																	
T. Gives Substantive Info.	6						42.1		5.4		.1	1.6	.2		1.4	.7	.3	
T. Gives Lab. Directions	7																	
T. Seeks Substantive Info.	8						.6		2.7			.1				6.5	1.9	
T. Looks at P's Work	9																	
T. Asks Procedural Ques.	10														.1	.1	.1	
T. Gives Procedural Direc.	11						1.4		.4			6.7	.5		.4	.1	.3	
T. Attends to Routines	12						.1		.2		.1	.3	1.3		.1		.1	
T. Supervises	13																	
P. Seeks Information	14		.2	.1			1.1		.1		.1	.5	.1		.4	.1		
P. Gives Information	15	.2	5.8	1.2			1.0		.5		.1				.1	1.6	.1	
Silence	16						.4		1.0			.3				.9	.8	
Total in Each Category		0.3	6.7	1.4	0.1	0	51.7	0	12.0	0	0.4	9.7	2.1	0	2.8	10.5	3.6	101

FIGURE A2 16x16 INTERACTION MATRIX BASED ON 4 LECTURE CLASSES OF BIOLOGY TEACHER #2
Figures in cells = % of 1971 observations, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15-2 is read as P Gives Information and T Accepts P's Response. (Column totals do not add up to 100% due to rounding).

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1	.2	.2				.3		.6			.1			.1	.6	.1	
T. Accepts P's Response	2	.2	.8				3.7		2.9			.1			.1	.8	.2	
T. Corrects P's Response	3	.1		.1			.2		.5			.2			.1	.6	.2	
T. Reprimands Pupil(s)	4				.5		.1		.2			.1				.1	.1	
T. Demonstrates	5																	
T. Gives Substantive Info.	6	.3	.1				21.3		4.5		.1	.6	.1		.6	.6	.9	
T. Gives Lab. Directions	7																	
T. Seeks Substantive Info.	8	.1	.1	.1	.1		.3		4.0			.2				9.4	2.6	
T. Looks at P's Work	9									.1	.1	.1						
T. Asks Procedural Ques.	10	.1			.1				.1		.1				.1	.6	.1	
T. Gives Procedural Direc.	11						.6		.4		.1	3.3	.1	.2	.1	.5	.6	
T. Attends to Routines	12						.1					.1	1.4	.1				
T. Supervises	13									.1	.1	.1		4.1				
P. Seeks Information	14			.1			.6				.1	.2			.8	.1		
P. Gives Information	15	1.0	7.8	1.6	.4		1.2		1.4		.5	.3		.1		4.0	.2	
Silence	16	.2			.2		.8		2.2			.4	.1			1.1	1.9	
Total in Each Category		2.2	9.0	1.9	1.3	0	29.2	0	16.8	0.2	1.1	5.8	1.7	4.5	2.0	18.4	6.9	101

FIGURE A3 16x16 INTERACTION MATRIX BASED ON 4 LECTURE CLASSES OF BIOLOGY TEACHER #3
Figures in cells = % of 1712 observations, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15-2 is read as P Gives Information and T Accepts P's Response. (Column totals do not add up to 100% due to rounding).

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1	.2					.3		.3			.3				.6		
T. Accepts P's Response	2		.2				2.2		3.7		.2	.8			.2	.6		
T. Corrects P's Response	3						.1		.4							.2		
T. Reprimands Pupil(s)	4				.5		.2		.3			.3				.1		
T. Demonstrates	5																	
T. Gives Substantive Info.	6	.2					23.2		4.4		.5	2.3	.2		.8	.7		
T. Gives Lab. Directions	7																	
T. Seeks Substantive Info.	8				.1		.5		1.3		.1	.4				12.1	.4	
T. Looks at P's Work	9									.1								
T. Asks Procedural Ques.	10						.3		.2		.2	.4	.2			1.6		
T. Gives Procedural Direc.	11				.3		2.6		1.5		.5	6.4	.2		.4	.6	.2	
T. Attends to Routines	12						.3		.1		.1	.2	1.0					
T. Supervises	13																	
P. Seeks Information	14		.2				1.1				.1	.2						
P. Gives Information	15	1.4	7.9	.8	.2		1.4		2.5		1.1	1.1				2.4	.2	
Silence	16								.2		.2	.1	.1			.2		
Total in Each Category		1.9	8.3	0.8	1.1	0	32.2	0	14.9	0.1	3.0	12.5	1.7	0	1.4	19.1	0.8	99

FIGURE A4 16x16 INTERACTION MATRIX BASED ON 4 LECTURE CLASSES OF BIOLOGY TEACHER #4
Figures in cells =% of 2014 observations, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15-2 is read as P Gives Information and T Accepts P's Response. (Column totals do not add up to 100% due to rounding).

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1	.9		.1			1.4		.3			.4	.1		.1	.2		
T. Accepts P's Response	2	.2	.3		.1		2.4		.8		.1	.3	.1		.1	.2		
T. Corrects P's Response	3			.1			.2		.3		.1	.1				.2		
T. Reprimands Pupil(s)	4				.5				.1			.1	.1					
T. Demonstrates	5						.3					.1						
T. Gives Substantive Info.	6	1.1	.1		.1	.2	46.8		3.6		.6	2.2	.3		.2	.4	.1	
T. Gives Lab. Directions	7							.2				.1						
T. Seeks Substantive Info.	8						.1		.9		.1	.2		.1	.1	5.6	.8	
T. Looks at P's Work	9																	
T. Asks Procedural Ques.	10						.3		.1			.3	.1		.1	.7		
T. Gives Procedural Direc.	11	.4			.1	.2	2.4	.1	.6		.3	7.0	.4		.4	.1	.3	
T. Attends to Routines	12	.1					.3				.2	.5	2.4		.1			
T. Supervises	13								.1									
P. Seeks Information	14	.1	.1				.4					.4	.1		.1			
P. Gives Information	15	.7	3.9	.8			.9		.7		.3	.4	.1			.8		
Silence	16	.1					.2		.4			.3				.2	.1	
Total in Each Category		3.6	4.3	1.0	0.8	0.4	55.7	0.3	7.9	0	1.7	12.4	3.7	0.2	1.2	8.4	1.3	103

FIGURE A5 16x16 INTERACTION MATRIX BASED ON 4 LECTURE CLASSES OF BIOLOGY TEACHER #5
Figures in cells = % of 1988 observations, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15-2 is read as P Gives Information and T Accepts P's Response. (Column totals do not add up to 100% due to rounding).

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
T. Praises Pupil(s)	1	.3					.1									.3		
T. Accepts P's Response	2						.3		.5							.4		
T. Corrects P's Response	3						.3		.1							.3		
T. Reprimands Pupil(s)	4				1.7		.1		.1			.7			.1	.3		
T. Demonstrates	5																	
T. Gives Substantive Info.	6	.2			.1		26.2	.1	1.6		.5	1.2			2.1	1.6	.2	
T. Gives Lab. Directions	7							.1										
T. Seeks Substantive Info.	8						.1		1.5						.1	4.6	.5	
T. Looks at P's Work	9																	
T. Asks Procedural Ques.	10										.1	.1			.1	1.2	.3	
T. Gives Procedural Direc.	11	.2			.6		.9		.4		.4	7.6	1.0		.7	1.6	.9	
T. Attends to Routines	12										.2	1.0	10.6					
T. Supervises	13																	
P. Seeks Information	14				.1		2.7		.2		.1	.6			1.2			
P. Gives Information	15	.1	1.4	.9	.4		2.7		1.9		.3	2.1	.2		.4	4.9	.2	
Silence	16						.2		.3		.2	.8	.1		.2	.4	.7	
Total in Each Category		0.8	1.4	0.9	2.9	0	33.6	0.2	6.6	0	1.8	14.1	11.9	0	4.9	15.6	2.8	98

FIGURE A6 16x16 INTERACTION MATRIX BASED ON 4 LECTURE CLASSES OF BIOLOGY TEACHER #6
Figures in cells = % of 2048 observations, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15-2 is read as P Gives Information and T Accepts P's Response. (Column totals do not add up to 100% due to rounding).

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
[illegible]	1	[illegible]																	
[illegible]	2																		
[illegible]	3																		
[illegible]	4																		
[illegible]	5																		
[illegible]	6																		
[illegible]	7																		
[illegible]	8																		
[illegible]	9																		
[illegible]	10																		
[illegible]	11																		
[illegible]	12																		
[illegible]	13																		
[illegible]	14																		
[illegible]	15																		
[illegible]	16																		
[illegible]																			

[illegible] INFORMATION MATRIX FOR [illegible] - [illegible] CLASSES OF BIOLOGY TEACHER #1
[illegible] in cell = [illegible] of the communication, rounded to nearest 0.1%. Each cell represents a particular [illegible] relationship. Read the first and second digit, e.g., cell .5-1 is read as P Gives Information [illegible] A about P. Exception: [illegible] do not add up to 100% due to rounding).

[illegible]		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
[illegible]	1	[illegible]			[illegible]		.2		.3		.1	.2				.3	.3	
[illegible]	2	[illegible]	.4	.3	[illegible]		1.2		1.9		.2	.4				.1	.3	
[illegible]	3		.3	.3	.1		.5		.3			.1				.2	.1	
[illegible]	4				.4		.4		.5		.1	.3			.1	.8	.1	
[illegible]	5																	
[illegible]	6	[illegible]	.1		[illegible]		15.1	.3	1.8	.2	.4	2.2	.2		.1	.2	.5	
[illegible]	7							.1		.1								
[illegible]	8	[illegible]			.1		.2		.8	.1	.1	.8				5.5	2.6	
[illegible]	9	[illegible]					.1		.3	.3	.1			.2	.1			
[illegible]	10		.1		[illegible]		.4		.3		.2	.3	.1		.1	.6	.1	
[illegible]	11		.1		[illegible]		.9		.1	.2	.1	5.5	.3		.1	1.0	.6	
[illegible]	12								.2	.1	.1	.3	2.3	.1			.1	
[illegible]	13						.1		.1	.1				.4				
[illegible]	14						.1		1							.1		
[illegible]	15	[illegible]					.1		1.3		.4	.5				3.2	.3	
[illegible]	16	[illegible]			[illegible]		1.0		1.2		.3	.8	.1			.9	1.5	
[illegible]		[illegible]	.7	[illegible]	[illegible]	[illegible]	17.2	1.2	12.4	2.0	2.4	11.4	3.0	0.7	0.5	12.9	6.5	102

[illegible] LECTURE CLASSES OF BIOLOGY TEACHER #8

[illegible] nearest [illegible]. Each cell represents a particular [illegible] next, e.g., cell 15-2 is read as P Gives Information [illegible] (Column totals do not add up to 100% due to rounding).

Category		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	[illegible]
[illegible]	1						.3								.1	.1		
[illegible]	2	.3	.3	.3			1.6		1.6			.6				.2		
[illegible]	3		.3	.4			.3		.3									
[illegible]	4																	
[illegible]	5					.1	.8											
[illegible]	6	1				.7	7.8		3.3		.8	1.5	.1		2.1	.7	.3	
[illegible]	7																	
[illegible]	8						.3		2.5			.3			.4	5.3	.5	
[illegible]	9									.3								
[illegible]	10						.3								.1	.6	.1	
[illegible]	11					.1	.3		.5	.4	6.2	.5			.1	.4	.3	
[illegible]	12										.3	1.8			.1			
[illegible]	13													.6				
[illegible]	14		1	1			.3		.3	.3	1.1				1.4			
[illegible]	15		1.5	.6			1.0		.5		.3	.7			.4	2.6		
[illegible]	16						.3		.3			.4				.1	.2	
[illegible]		.6	.3	.3	.1	.1	15.2	.1	9.2	1.3	.4	11.6	2.4	0.6	6.1	10.0	1.4	99

TABLE 45 [illegible] INTERACTION MATRIX BASED ON 4 ACTIVE CLASSES OF BIOLOGY TEACHER #9
Figures in cells = % of [illegible] observations rounded to nearest 1.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15-2 is read as P Gives Information and T Accepts P's Information. (Column totals do not add up to 100% due to rounding).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	sum
[illegible]	1	[illegible]		[illegible]			.2		.3			.2				.1		
[illegible]	2		[illegible]				1.1		.7			.4				.1		
[illegible]	3			[illegible]			1		.3			.3				.1		
[illegible]	4											.1						
[illegible]	5																	
[illegible]	6	.3					2.1		2.4		.4	2.1			1.2	.9		
[illegible]	7							.5				.3						
[illegible]	8						.3		1.3			.3				3.4	.4	
[illegible]	9								.2			.2						
[illegible]	10						.3			1	.1				.1	.7		
[illegible]	11			[illegible]	1.3	.3	.5		.3	10.1	.3				.9	.9	.2	
[illegible]	12						.1		.1	.1	4.3	.1						
[illegible]	13											.3						
[illegible]	14				.3		.2	.2	.3						.4	.1		
[illegible]	15	3.1	.4		.4		.3		.3	.3	.1				.1	2.6		
[illegible]	16				.1					.1	.1					.1	.1	
[illegible]	sum	3.4	.4	1.4	1.4	.3	6.1	.5	8.9	11.3	5.4	8.1	4.3	0.1	2.7	5.9	0.7	99

TABLE 4.1 [illegible] INTERACTION MATRIX BASED ON [illegible] LECTURE CLASSES OF HIGHEST TEACHER #10
Figures in cells = % of [illegible] communications rounded to nearest 0.1%. Each cell represents a particular sequence of behavior [illegible] and others next, e.g., cell 15-2 is read as P Gives Information and P accepts P's [illegible]. (Column totals do not add up to 100% due to rounding).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	sum
[illegible]	1	.2					.1			.1			.1		.1			
[illegible]	2		.2				.4		.4	.1	.1	.1	.1	.2	.1	.1		
[illegible]	3						.1		.1			.1						
[illegible]	4				.3		.1								.1			
[illegible]	5	.1				2.7	.4	.5	.2	.1	.1			.1		.6		
[illegible]	6		.2			.5	4.5	.3	.6	.1	.3	.5	.1	.5	1.1	.3		
[illegible]	7					.1	2.7	1.4	.7	.1	.2	.2	.1	.7	.9	.7		
[illegible]	8					.3	.1	.4	1.6							2.8	.1	
[illegible]	9		.1				.4	1.9	.2	7.9	.2	.1	.1	.1	.3	.1		
[illegible]	10					.1	.1	.2	.1	.1	.7	.2	.4	.2	.1	1.7		
[illegible]	11		.1				.6	.3	.2	.3	.5	3.5	.7	.4	.5	.2	.2	
[illegible]	12							.2	.1	.1	.3	.5	9.0	.2	.5	.1	.1	
[illegible]	13						.1	.2	.3	.2	.1	.3	.2	6.5	.5	.1		
[illegible]	14						.2	.1	.2	.2	.5	1.3			.4			
[illegible]	15	.1	.1	.1	.1	.1	.6	.8	.9	.3	.4	.7	.3	.1	.2	.2		
[illegible]	16						.1		.1		.1	.1			.1			
[illegible]		4	1.3	1.3	1.8	4.3	17.0	6.0	6.9	11.3	7.5	11.3	12.0	8.9	5.9	8.4	101	

FIGURE 21. [illegible] INTERACTION MATRIX BASED ON A LEARNABLE TASKS OF BIOLOGY TEACHER #1
Figures in cells = % of all interactions, rounded to nearest 0.1%. Each cell represents a particular sequence of behavior. Read row first and column next, e.g., cell 15-2 is read as P Gives Information and T Accepts P's Response. (Column totals do not add up to 100% due to rounding).

Sequence		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
P. [illegible]	1						.3									.2		
P. [illegible]	2		.4	.1		.1	1.3	.1	1.3			.4	.1	.1	.2	.1		
P. [illegible]	3					.1	.4	.1	.2			.1				.3	.1	
P. [illegible]	4				.3	.2						.1				.1		
P. [illegible]	5				.1	6.7	.7	.7	.1		.3	.1	.1		.2	.1		
P. [illegible]	6				.1	.7	21.7	.2	2.2	.2	.1	1.3	.6	1.0	1.2	.7	.1	
P. [illegible]	7			.1	.1	.2	.2	1.4	5	.3	.1	.1				.2		
P. [illegible]	8						.3		1.6	.1	.1	.3			.1	4.9	1.2	
P. [illegible]	9			.		.	3	.2	1	.5	.2	.1	.1	.3	.1			
P. [illegible]	10					.		..	.1	.1		.1	.1		.2	1.6		
P. [illegible]	11				.	.	1.5	.1	5	.1	.3	5.9	.7	.3	.4	.2	.3	
P. [illegible]	12						.3	.1	.6	.1	.1	.7	6.0	.3	.1			
P. [illegible]	13						.1			.6	.2	.4	.4	2.2	.4	.1		
P. [illegible]	14	.1	.1	.			.5		.3	.1	.4	.4	.1		.4			
P. [illegible]	15	.1	.4	.3	.1	.5	1.3	.1	.4		.6	.5	.2	.1	.1	1.3	.1	
P. [illegible]	16	.1			.1		.1		.1			.3			.1	.5	.2	
Total No. Event Categories		1.4	.1	1.1	1.5	5.	.1	3.3	8.5	2.1	2.4	10.6	8.6	4.3	3.5	10.3	2.0	102

FIGURE 5.2 [illegible] INTERACTION MATRIX BASED ON 4 LABORATORY CLASSES OF BIOLOGY TEACHER #2 [illegible] cell = 1 of 102 interactions recorded in Segment 1.12. Each cell represents a particular sequence of behavior. Read the first and second event, e.g., cell 15-2 is read as P Gives Information and T Responds P's Response. (Column totals do not add up to 100% due to rounding).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
[illegible]	1						.1			.1		.1		.1	.1			
[illegible]	2						.2	.2		.1		.2	.1	.3	.1			
[illegible]	3	.1		.2	.1			.1	.1	.1						.1		
[illegible]	4				.3			.1				.1	.1	.1	.1	.1		
[illegible]	5					.5	.2	.6	.1	.1					.1	.2		
[illegible]	6	.1		.1	.1	.3	2.6	.3	.3	.1		.1	.1	.1	.1	.1	.1	
[illegible]	7	.4			.1	.2	7	2.3	.1	1.3	.2	.6	.2	.6	.4	.1	.2	
[illegible]	8	.2					.1	.1	.3			.2		.1	.1	1.8		
[illegible]	9	.1	.2	.2			.2	1.2	.5	9.8	.3	.3	.3	.6	.1	.4		
[illegible]	10								.1	.3	.1	.2	.2		.2	.8	.1	
[illegible]	11						.1	.7	.2	.4	.1	3.3	1.5	.6	.7	.4	.1	
[illegible]	12						.1		.1	.4	.5	.7	22.4	.5	1.1	.1	.1	
[illegible]	13							.2	.1	1.1	.2	.2	.4	7.0	.1			
[illegible]	14	.1	.1	.1	.1		.1	1.1	.3	.1	.3	1.4	.1		1.1	.1		
[illegible]	15	.1	.1	.1	.1	.1	.1	.1	.1	.3	.1	.5	.3	.1	.1	.6		
[illegible]	16							.3				.3	.1		.1			
[illegible]		1.1	1.1	1.2	1.2	1.8	5.3	14.7	2.6	15.8	1.9	12.1	25.8	10.1	7.3	4.8	0.6	102

[illegible] 4.1 [illegible] INTERACTION MATRIX BASED ON 4 LABORATORY CLASSES OF BIOLOGY TEACHER #3
[illegible] in cell = 1 of 102 observations, rounded to nearest 0.1%. Each cell represents a particular sequence of [illegible]. Read the first and column next, e.g., cell 15-2 is read as P Gives Information and T Receives P's Response. (Column totals do not add up to 100% due to rounding).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
P. [illegible]	1	.4					.3	.4	.2	.3	.1	.2	.1	.1	.1	.5		
P. [illegible]	2		.1	.1			.4	.3	.4			.4	.1		.1	.2	.1	
P. [illegible]	3			.1			.3		.2			.1				.1		
P. [illegible]	4				.2	.1	.3	.1	.1				.1			.2		
P. [illegible]	5					1.8	.2	.4	.1			.1	.1		.1			
P. Gives Information Info.	6	.1			.1	.1	2.2	.7	1.8	.2	.3	.5	.1	.1	.3	.7		
P. Gives Info. Directions	7	.4				.3	.4	6.8	.3	.7	.3	.3	.4	.5	.3	1.1	.1	
P. Seeks Information Info.	8	.2			.1	.1	.3	.1	1.2	.1		.1			.1	6.9	.1	
P. Seeks or Gives Info.	9	.1				.1	.2	.4	.2	2.7	.2	.2	.1	.2	.2	.1		
P. Asks Procedural Info.	10	.1						.1	.2	.1	.1	.3	.2	.1	.1	2.4		
P. Gives Procedural Info.	11	.1	.1		.1	.2	.5	.4	.4	.1	.7	6.2	1.2	.2	.5	.4	.1	
P. Attends to Learner	12					.1	.1	.4	.3		.1	.9	7.8	.1	.3	.1	.1	
P. Suggestions	13	.1			.1		.1	.1	.1	.3	.1		.2	3.1				
P. Gives Information	14		.1	.1	.1	.2	.4	.6	.1	.1	.1	.6			.3	.1		
P. Gives Information	15	.4	1.4	.5	.1	.2	.5	1.1	1.8	.2	1.8	1.4	.3	.3	.5	4.6	.1	
P. Laughs	16						.1				.1	.3				.1		
Percent of Total Responses		.9	1.5	1.4	1.5	3.5	4.1	3.5	5.2	2.4	3.1	2.8	16.7	4.7	2.9	17.4	0.6	101

TABLE [illegible] SEQUENTIAL MATRIX BASED ON A QUANTITATIVE ANALYSIS OF ECOLOGY TEACHER #4
Figures in cells = % of [illegible] interactions recorded in sequence I-J. Each cell represents a particular sequence of events (read from the left and across rows, e.g., cell 15-1 is read as P Gives Information and T Accepts It; Percentages in cells may not add up to 100% due to rounding).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
[illegible]	1	.3	.1			.3	.2	.2	.1	.2		.3	.3		.1			
[illegible]	2		.1	.1			.5	.1	.3			.2	.1		.1		.1	
[illegible]	3						.2									.1		
[illegible]	4				.1										.1			
[illegible]	5	.2				1.6	1.3	1.5	.3		.1	.2	.1		.2			
[illegible]	6	.3	.2		.1	1.8	2.4	1.2	.7	.2	.3	1.5	.8		1.5	.6		
[illegible]	7	.3				1.8	1.3	7.4	.2	.6	.1	1.2	.8	.1	.9	.2		
[illegible]	8						.2		.8	.1		.1				2.3	.1	
[illegible]	9	.1					.3	.2	3.0	.1	.2	.2	.1		.3	.3		
[illegible]	10						.1	.3		.2	.1	.1			.1	1.2		
[illegible]	11	.1	.1			.4	.3	2.1	.2	.5	.3	6.5	2.8	.1	1.4	.3	.2	
[illegible]	12					.1	.5	.1	.1	.3	.1	1.7	1.5		.9	.3		
[illegible]	13									.3	.1		.3	.1				
[illegible]	14		.1	.1		.1	.5	.3	.1	.4	.1	1.5	.3		.3	.1		
[illegible]	15	.1	.1	.1		.1	.8	.1	.3	.1	.1	.5	.4		.2	1.1		
[illegible]	16								.2			.2						
[illegible]		1.6	1.0	.6	.2	6.1	11.1	14.3	7.2	2.1	1.3	25.4	8.4	.4	10.3	6.5	0.4	101

TABLE 4.2 [illegible] INTERACTIVE MATRIX BASED ON A [illegible] CLASSES OF BIOLOGY TEACHER #5
Figures in cells = % of [illegible] number is nearest 1.2%. Each cell represents a particular sequence of [illegible] Read as 1st and 2nd [illegible], e.g., cell 15-2 is read as P Gives Information and P Accepts P's Statement. (Column totals do not add up to 100% due to rounding).

[illegible]		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
[illegible]	1	.1										.1						
[illegible]	2		.2				.3		.6	.1		.1		.1	.2	.1		
[illegible]	3			.1			.2		.2						.1			
[illegible]	4				1.0	.1	.1	.1	.1		.1	.1	.1	.2	.1			
[illegible]	5					3.3	.3	.6		.1		.2	.1	.1	.3			
[illegible]	6	.1			.1	.3	4.9	.4	.4	.1	.2	.5	.3	.2	1.4	.6		
[illegible]	7				.1	.6	.3	6.6	.2	.2	.1	1.0	.3	.4	1.3	.1	.1	
[illegible]	8						.1	.1	.7	.1			.1	.1	.1	2.9	.1	
[illegible]	9		[illegible]					.4	.3	2.2	.1	.1	.2	.3	.4	.1		
[illegible]	10				.1	.1		.1			.3	.1	.4	.1	.3	.7		
[illegible]	11				.2	.3	.1	.5	.2	.1	.4	8.6	1.3	.5	1.5	.3	.3	
[illegible]	12				[illegible]	.1	.1	.1	.1	.1	.3	.1	7.2	.3	1.2	.1		
[illegible]	13				.1		.1	.1	.1	.4	.2	.2	.1	5.4	1.2			
[illegible]	14		.1	.2	.1	.2	2.1	1.1	.5	.5	.3	1.6	.3		.7	.1		
[illegible]	15		1.3	.1	.3		.4	.4	.3	.3	.2	.5	.2	.3	.2	.8		
[illegible]	16							.1				.3	.8	.1			.2	
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.5	[illegible]	8.1	5.0	5.8	0.7	100

[illegible] represents a particular [illegible] Information [illegible] rounding).

[illegible]		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	[illegible]
[illegible]	1															.1		
[illegible]	2						.4		.5			.1		.2	.2			
[illegible]	3								.1						.1			
[illegible]	4				[illegible]			.1				.1	.1	.1	.1		.1	
[illegible]	5					1.5		[illegible]					.1		.2			
[illegible]	6					.1	4.4	.3	.8	.1		.2	.2	.2	.8	.2		
[illegible]	7					.7	.3	6.5	.2	.4	.1	.2	.3	.9	1.9	.1		
[illegible]	8								.8	.1					.1	2.4	.3	
[illegible]	9	[illegible]	[illegible]			.1		.5	.2	2.6	.1	.1	.1	.5	.7			
[illegible]	10									.1		.1			.1	.4		
[illegible]	11				.1		.1	.3	.2	.2	.1	8.0	1.3	1.3	1.6	.2	.4	
[illegible]	12				[illegible]			.1		.1	.1	1.1	5.3	.7	1.3			
[illegible]	13				.1			.3		.6	.1	.6	.6	12.3	1.7	.1		
[illegible]	14		[illegible]	[illegible]	.1		1.3	2.4	.4	.9	.2	2.5	.3		.6	.1		
[illegible]	15	[illegible]	[illegible]	[illegible]	[illegible]		.4	.3	.7	.7	.1	.2	.2	.1	.2	.7	.1	
[illegible]	16								.3			.4	.1		.1	.1	.5	
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.7	4.4	1.4	102

[illegible] 17

[illegible]. Each cell represents a particular sequence of [illegible] e.g., [illegible] [illegible] Information [illegible]

[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	11	12	13	14	15	16	[illegible]
[illegible]	1	.1				.1		.1		.1	.1	.1	.1	.3	.1	.4		
[illegible]	2	.1	.1				.1	.1		.1	.1	.1		.1		.1		
[illegible]	3				.1		.1	.1	.1	.1		.1		.9		.1		
[illegible]	4				.1			.1	.1	.2	.1	.1	.1	.1	.1	.1		
[illegible]	5					2.2	.3	.5		.2	.1	.1						
[illegible]	6	.1			.1	.1	2.7	.3	.2	.3		.1		.2	.1	.3		
[illegible]	7				.1	.1	.1	3.8	.1	.8	.2	.1	.1	.6	.1	.1	.1	
[illegible]	8	.1					.1		.1	.3	.1	.1				2.0	.1	
[illegible]	9	.4	.1	.1	.1	.1	.1	.8	.9	15.6	.7	.1	.1	1.3	.6	.3		
[illegible]	10				.1			.1		.2	.1	.1			.1	2.4	.1	
[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.6	.1	1.1	.4	.7	.1	.2	.2	
[illegible]	12							.1		.1	.3	.1	11.4	.1	.1			
[illegible]	13								.1	1.9	.2	.1	.1	12.0	.1			
[illegible]	14	.1						.5	.1	.7	.3	.1	.1		.9	.1		
[illegible]	15	.3								.8	[illegible]	.5	.1	.6	.1	.8	.1	
[illegible]	16										.1	.1	.2		.1		.5	
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.4	2.5	[illegible]	2.4	7.0	1.1	99

[illegible] Each cell represents a particular [illegible]

[illegible]		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
[illegible]	1		[illegible]							.1		.1		.1		.1		
[illegible]	2						[illegible]	[illegible]						.3				
[illegible]	3						.1							.1				
[illegible]	4				.1									.1				
[illegible]	5					.1	.1											
[illegible]	6						1.4	.3	.1	.3	.3	.4	.1	.5	.1	.5	.1	
[illegible]	7						.7	.1		.3	.3	.3	.1	.6	.2	.2		
[illegible]	8				.1		.4	.3	.5	.1						2.1	.3	
[illegible]	9	.1	.1				.3	1.8	.5	[illegible]	.9	.1		1.3	.3	.2		
[illegible]	10						.1			.3	.1	.3			.1	1.4		
[illegible]	11	.1					.3	.3		.3	.2	.8	.1	.5	.2	.1		
[illegible]	12						.3			.2		.1	8.8	.5	.2		.1	
[illegible]	13							.1	.1	2.3	.6	.5	.7	10.6	.5	.2		
[illegible]	14		.2				.3	.6	.1	.1	.5	.1			.5			
[illegible]	15	.1	.7	.7			.7	.1	.1	.9	.1	.5	.1	.5	.2	.6		
[illegible]	16						.3		[illegible]			.1				.1	.2	
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.5	5.4	15.7	15.2	2.9	6.1	0.7	98

[illegible]